Advancing data analytics model in examining economic impact of the United States gaming industry

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Advancing data analytics model in examining economic impact of the United States gaming industry

by

Asit Bandyopadhayay

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Hospitality Management

Program of Study Committee:
Tianshu Zheng, Major Professor
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The student author, whose presentation of the scholarship herein was approved by the program of study committee, is solely responsible for the content of this dissertation. The Graduate College will ensure this dissertation is globally accessible and will not permit alterations after a degree is conferred.

Iowa State University
Ames, Iowa
2019

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DEDICATION

This dissertation is dedicated to my father Late Shri D. C. Bandyopadhayay and my mother Smt. Chabi Bandyopadhayay. Without their blessings and support it would have never been possible to complete this journey. I would also like to dedicate this work to my elder brother Ashim Banerjee for his ever-ending support in this journey.

Personally, I am delighted to dedicate this dissertation to my dearest wife, Sucharita, for always encouraging me in fulfilling this Hugh task. Her sacrifice, patience, and devotion in achieving our common goals were my key driving force to accomplish this work. I would also like to dedicate this dissertation to my two wonderful kids, Srija and Aashuman, who have always been a great motivator for me in joining this program and successfully completing it. My constant effort is to be a better father to them. Finally, this work is dedicated to the Almighty God and Nirmal Bhahmachari without whose blessings this dissertation would never been completed.
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Casino industry is one of the strongest growing industries in the United States (US). Recognizing the importance of this industry, this study suggested a new efficiency measurement technique for casino industry. The proposed efficiency measurement technique extends the quantitative data analysis methodology for business performance measurement and can be applied to other research and business communities.

This study measures efficiency of casinos operating in the US. Casinos from 24 states where gaming is legalized and whose basic information is provided with the American Gaming Association were studied. The results helped in providing a comprehensive index for measuring overall efficiency of the casinos by comparing identified states of the US and thereby recognizing the casino economic impact on the society. The output-oriented Data Envelopment Analysis (DEA) were applied to calculate casino efficiency scores and performances. These models helped in determining the optimal benchmark for commercial casinos. The results demonstrate that significant economic impact created by more than half of the states of the US. Furthermore, the quantitative model proposed in this study is a pioneering work. It measures Malmquist Productivity Index (MPI) to evaluate the efficiency change over time for the casino industry of the US by considering both optimistic and pessimistic frontiers of DEA model. It has been observed that the Malmquist Index values calculated using double frontier DEA method are providing a panoramic view of the productivity changes over time. Results are more accurate than previous studies unfolding a different perspective of the US gaming industry.

This study also provides an explanation of the US gaming tourism paradox in the hospitality sector. From the outcome it has been observed that the non-destination gaming states were performing well during post-recession years which indicates if consumers find less
expensive ways to spend their discretionary income, they will always be attracted towards that. Therefore, non-destination states’ casino marketers should promote their business in the local markets, through investing more and providing better gaming experiences to their customers, which in turn will improve the local economy through more job creation, better tax revenue collection etc., thereby improving the economic condition of the society.
CHAPTER 1. GENERAL INTRODUCTION

The global consumer market is moving into an economy where experience is the most valued commodity (Pine & Gilmore, 2011). Competitiveness in this experience economy is more on producing and delivering an experience for the end consumers rather than speed to market. Such experience will lead to loyal consumers with repeat business and viral demand through positive word-of-mouth. Casino gaming is more of an experience economy where the industry revenue increases according to the extent to which consumers enjoy their experience (Chang, 2018). This dissertation attempts to examine the economic impact of the US gaming industry by extending the existing quantitative performance measurement model available in the literature. This chapter briefly describes the background of the casino industry, research problem, purpose, and definitions of important terms. Finally, the organization of this dissertation has been presented at the end of this chapter.

Background

Evidence of casino gaming has been discovered in most ancient cultures including Egypt, Athens, India, China, and Rome (Petry, 2005), which indicates that the culture of gambling as a social activity has been maintained for more than 4,000 years. Casino gaming has been a part of American culture since colonial times, but the development of casino gaming has long been a controversial topic for the public (Rose, 1995; Walker, 2013). Public attitudes toward gambling activities were based on both community benefits and individual interests (Nichols, Tosun, & Yang, 2015). Lee, Kim, and Kang (2003) found that casino gaming can promote local tourism thereby bringing more personal income and increasing employment opportunities in a given community. Researchers have found that the gaming industry can stimulate local economies and help resist economic recession (Giacopassi, Nichols, & Stitt, 1999; Nicholos et al., 2015). In addition, the casino industry could create new purchasing power, and generate more tax revenues for the government (Perdue, Long &
Kang, 1995; Humphreys & Marchand, 2013). However, opponents argue that casino gaming can harm a community by bringing with it various social problems like organized crime, personal health issues, gaming addiction, bankruptcy, family dissension etc., and eventually threatening the security in local communities (Hsu 2000b; Grant Stitt, Giacopassi & Nichols, 2003; Lee & Back, 2006; Koo, Rosentraub, & Horn, 2007). Walker and Sobel (2016) noted that the social impacts of gambling are multifaceted, generally negative in nature, and are often attributed to disordered gamblers. However, excluding drunk driving, recent studies have found that there is a weak correlation between casinos and both crime and bankruptcies (Hsu 2000a; Stitt et al., 2005; Lee & Back, 2006; Koo, Rosentraub, & Horn, 2007). The social impact of casinos is more subjective than the economic impact as they are abstract in nature. However, Lee and Back (2006) specified six positive social factors associated with casinos — investment and business, tourist spending, standard of living, tax revenues, employment opportunities, and finally personal income.

In the context of the United States, casino gaming industry is one of the key areas in hospitality business and it has established its strong economic influence within the industry (Garrett & Nichols, 2008). According to American Gaming Association (AGA) commercial casino industry survey, the industry has been one of the strongest growing industries in the country (AGA, 2016). As the industry is growing, more and more state policy makers have come to view legal casinos as a way to lighten their fiscal stress (Lambert, Srinivasan, Dufrene & Min, 2010). Consequently, an increasing number of states have legalized casino gaming in one form or another and it has been accepted as one the most significant drivers of increased tourism and economic development (Chhabra & Gursoy, 2007; Walker, 2013).

**Gaming Industry during Economic Recession**

Most of the industries normally are affected by economic recession, and the gaming industry is also no exception. However, it has been observed that gaming revenue has not
declined during all recession periods. For instance, during the recession attributed by dot com bubble burst in the year 2001, overall gaming revenues increased by 3.1 percent, even as economic activity in the other industries decreased (AGA, 2000-2002). Eventually, industry people started thinking that casino gaming industry might well be recession-proof. This image of a recession-proof gaming business was shattered during the recession of 2008. This recession was being felt by the end of the year 2007 and extended till mid of 2009 (here in this study we call it as the recession of 2008). In the year 2008, the US gaming industry witnessed a 3.47 percent decrease in annual gross gaming revenue, the first annual decrease since 1998. Annual gross gaming revenue fell from $37.52 billion in 2007 to $36.22 billion in 2008 and then to $34.28 billion in 2009 (AGA, 2009-10). All these data have led to a conclusion that the gaming industry is no longer recession-proof (Linn, 2008). However, these conclusions are based on industry-wide data and generally do not consider localized gaming markets. There is evidence which suggests that certain markets might not be affected by the recession in a considerable way. For example, as per Iowa Racing and Gaming Commission (2008-2012), after two years of slight decrease during the recession, Iowa’s gaming revenue rebounded in 2011 and exceeded what it was before the recession. Therefore, comparing with the nation’s average, Iowa’s gaming industry was minimally affected by the recession and immediately started to grow afterward (Zheng, Farrish, Lee & Yu, 2013).

Till the year 2011, after two consecutive years of growth following the recession, total gaming revenue aggregated across country did not reach pre-recession levels. Total nationwide gaming revenue in 2011 was at the 95% level of that of 2007 (AGA, 2012). As a result, some researchers concluded that the gaming industry is definitely affected by recession (AGA, 2012-13; Legg & Tang, 2011). However, such conclusions are based on industry-wide aggregated data and they do not consider the scenario of the local gaming markets. The micro level data suggest that certain state gaming markets are either not
affected by the recession or their impact is too minimal. For example, as per AGA report (2008-2012), the consumer spending on casino gaming for the state of Missouri had never gone down during the recession. In fact, it has shown a steady increase in consumer spending on casino gaming till 2011. Therefore, it is also an interesting gaming research agenda that would lead to a research question – was the legalized gaming business across the US affected by the recession of 2008?

**Importance of the Study**

Although gaming is a subject of controversy, the gaming industry is expanding at a rapid pace across the globe and therefore, the opportunities associated with this industry are also expanding (Lee & Back, 2006). Over the time, casino gaming has been transformed into a mainstream activity, and most of the researchers consider it as fundamentally similar to many other recreational options (Kwon & Back, 2009). Except for two states in the US (Hawaii and Utah) all of the states have legalized some form of commercial gaming. Internationally, casinos comparable with those in Las Vegas have expanded to Asian cities such as Macao, Singapore, Kuala Lumpur etc. The US casino industry received 81.41 million casino visitors in the year 2016. Also, in the same year, US commercial casinos employed 335,516 people, paid wages of $14.04 billion, contributed $8.948 billion in direct gaming taxes, and earned $38.96 billion in gaming revenue (AGA, 2017).

The recession of 2008 had an enormous negative impact on the hospitality gaming industry (Palenik, 2011) as gaming industry is highly dependent on the business cycle and consumer discretionary spending. Palenik (2011) in the same study found that, while the economy officially came out from recession in the summer of 2009, the casino gaming industry suffered one more year to come out from its continued impact. Past studies identify the effect of this recession on hospitality industry as a whole, however, they did not see its impact specifically on the US gaming industry (Spencer, 2008; Pearce, 2012; Poudyai,
There are plenty of researches on measuring operational efficiency of hospitality industry (Altin et al., 2018). Some of the studies used (Anderson et al. 1999; Chen, 2007; Hu et al., 2010) parametric efficiency measure to estimate the efficiency of hospitality industry where others used non-parametric efficiency measurement methods like data envelopment analysis (DEA) (Fernández & Becerra, 2015; Aissa & Goaied, 2016). As this study focuses on casino gaming industry, we did not find any comprehensive methodology in calculating gaming industry performance and productivity changes over a period of time. Therefore, this study attempts to measure performance by calculating productivity changes of casino gaming industries during pre- and post-economic recession periods (considering 2009 as the baseline year) by comparing two economies.

**Purpose of the Study**

In accordance to the growing importance of casino industry, many researchers have turned their attention to examining the economic impacts of gaming (Walker & Sobel, 2016; Forrest, 2007). However, in spite of the growing importance of legalized gaming, very limited researchers have been able to publish empirical research on it (Walker, 2009). There are a number of reasons behind it. One of the most important reason is quality data on the impact of casinos on host communities is hard to get (Zheng & Hung, 2012). Industry-sponsored studies strongly suggest that local and state economies and community can be benefitted immensely from the gaming industry (Andersen, 1996; Walker, 2013). To that end, local governments have taken a favorable view of casinos in the context of economic benefits (Ham, Brown & Jang, 2004). However, the industry-sponsored studies are open to criticism on the grounds that they are susceptible to bias and having a conflict of interest, as those studies are conducted by the institutions that supported gaming legalization in the first place.
(Wohl & Wood 2015). Furthermore, these studies primarily talk about taxes paid to the government and employees hired by the casino industry and ignore other factors that have a direct impact on the quality of life within a community.

The operational efficiency of hospitality industry has drawn much attention where it has been measured through various financial indicators such as cost-volume-profit index, lodging index, revenues, and sales receipts (Fay, Rhoads, & Rosenblatt, 1971; Jagels & Coltman, 2004; Van Doren & Gustke, 1982; Kimes, 1989; Wassenaar & Stafford, 1991; Baker & Riley, 1994). However, these financial indicators only portray output performance. A large number of past research uses efficiency measures to evaluate the performance of hospitality industry while considering both multiple inputs consumed and multiple outputs generated. Some of them (Anderson et al. 1999; Chen, 2007; Hu et al., 2010) have introduced the parametric efficiency measure to estimate the efficiency of hospitality industry using econometrics models. Non-parametric efficiency measurement methods like data envelopment analysis (DEA), are frequently applied techniques in the hotel industry (Fernández & Becerra, 2015; Aissa & Goaied, 2016). These efficiency measurement techniques show better results than other performance indicators like sales growth, financial ratios, profitability etc. In spite of known importance of efficiency measurement, very limited study exists in the literature that talks about the operational performance of casinos precisely. Therefore, the specific objectives of this study are to:

1. Identify whether state-wide legalized casinos across the US being operated with their full operational efficiency or not.
2. Identify the impact of the recession of 2008 on the US gaming industry.
3. Evaluate casino performance and identify useful benchmarks and thereby improve efficiency of comparatively less efficient casinos.
4. Introduce a novel methodology for efficiency measurement in providing a comprehensive view of time-based productivity changes.

This is a contemporary research and the findings of this study will help casino developers and policy makers to identify the impact of casinos on local community and framing strategies to aggressively promote their business in local markets during an economic downturn. This way, regional customers can experience a similar environment with significantly less spending because they will not have to travel to a big destination. It will also help casino industry practitioners in developing and/or running their existing casinos in a strategic manner. Additionally, this dissertation aims to contribute to the present literature by providing a method for performance measurement.

**Definition of Terms**

*BCC Efficiency*: Efficiency measurement using data envelopment analysis model developed by Banker, Charnes, and Cooper (BCC)

*CCR Efficiency*: Efficiency measurement using data envelopment analysis model developed by Charnes, Cooper and Rhodes (CCR)

*Decision Making Unit (DMU)*: A set of peer units that are homogenous in nature, are commonly described as a decision making unit.

*Data Envelopment Analysis (DEA)*: It is a productivity analysis tool that uses multiple inputs and outputs in evaluating relative efficiencies of decision making units

*Discretionary Spending (DS)*: Optional spending set by an individual each year at their discretion, which is typically based to their income for that year.

*Double Frontier Data Envelopment Analysis (DFDEA)*: A DEA model that considers both optimistic as well as pessimistic efficiency frontiers.

*Double Frontier MPI (DFMPI)*: Malmquist Productivity Index value calculated using both optimistic as well as pessimistic efficiency frontiers.
**Gross Gaming Revenue (GGR):** It is a key metric used by gambling and betting companies, which refers to the difference between the amount of money players wager minus the amount they win. Gross gaming revenue is equivalent to sales and not profit. It is also called as game yield. Other way, it can also be defined as the amount a gaming operation earns before taxes, salaries and other expenses are paid.

**Gaming Tax Revenue (GTR):** It represents only specific gaming taxes paid by casinos out of monies won from patrons. It does not include various other taxes that apply to casinos.

**Malmquist Productivity Index (MPI):** It is an index that evaluates the efficiency change over time. It is named after Professor Sten Malmquist, who proposed this concept.

**Optimistic MPI (OMPI):** MPI calculated based on the DEA model that considers optimistic efficiency frontiers.

**Per Capita Wage (PCW):** It measures the average income earned per person in the casino industry in a specified year. It is calculated by dividing the total income earned in that year by the total number of employees employed that year.

**Pessimistic MPI (PMPI):** MPI calculated based on the DEA model that considers pessimistic efficiency frontiers.

**Slot Machine (SM):** It is a gaming machine (kind of a vending machine) that normally operated by inserting coins into the given slot and pulling a handle that activates a set of spinning symbols on wheels. The payoff is decided by the final alignment of spinning symbols and is released into a container located at the bottom of the machine.

**Time Economies (TE):** Economies of two different time periods.

**Total Employee Wage (TEW):** It is the total income earned by all the employees employed in the casino industry in a specified year for a given state.
Dissertation Organization

This dissertation contains six chapters and organized in the following manner.

Chapter one talks about introduction, background and importance of the study, purpose of the study while mentioning its objectives, and finally definitions of terms. Chapter two provides a review of literature and chapter three presents the study’s methodology. Chapters four and five contains two manuscripts that have been prepared to be submitted in two Journals. Chapter six presents general conclusions, implications, and limitations of the study.

Reference lists are provided at the end of each chapter.

References


CHAPTER 2. LITERATURE REVIEW

This chapter provides a review of recent literature on economic impact, precisely the impact created by the casino industry; impact of economic recession on the casino industry and different performance measurement models in the context of the hospitality and casino industry. It looks at various performance measurement models for comparing economies over different time periods and provides underlying theoretical foundations for this study. Subsequently, it sets the context for developing a new performance measurement model for comparing different time economies.

Economic Impact

Economic impact of a firm is the macroeconomic effect on commercial activity, employment, or incomes produced by that firm. An economic impact analysis attempts to measure or estimate the change in economic activity in a specified region, caused by a specific industry, organization or any other politico-economic event (Weisbrod & Weisbrod, 1997). Economic impact usually measures changes in business revenue, business profits, personal wages, and jobs because of the economic activity. The economic event analyzed can include implementation of a new policy or project, or may simply be the presence of a business or organization. An economic impact analysis is commonly conducted when there is public concern about the potential impacts of an industry, firm, project or even for a policy (Romer, 2012).

Economic impact analysis often estimates multiple types of impacts such as output impact, value added impact etc. An output impact is the total increase in a firm’s sales revenue. A more conservative measure of economic activity is the value-added impact, which estimates the increase in the study region’s gross regional product (GRP). The GRP is very similar to the nation’s gross domestic product (GDP), but it is measured in the context of the local economy. Such impact estimates the increase in local employee wages plus local
business profits. However, the value-added impact may overstate local profits when they are transferred overseas (Sharpley, 2015).

An even more conservative measure of economic impact is the labor income impact, which represents the increase in total money paid to local employees in the form of salaries and wages. The increases in income may come in the form of raises and/or increased hours for existing employees, or new jobs for the unemployed. This is a measure of the economic impact on just personal incomes, not business revenues or profits. A similar measure is the employment impact, which measures the increase in the number of total employees in the local region. Instead of measuring the economic impact in terms of money, this measure presents the impact on the number of jobs in the region (Romer, 2012). Another measure of economic impact is the property value impact, measuring the increase in total property values, and is a reflection of generated income and wealth, both for personal houses as well as business locations (Wenz, 2007).

While measuring economic impact, costs and consumption are generally used as some of the important variables (Marshall & Shortle, 2005). To measure the economic impact created by any industry, we need to see how efficiently that industry boosts employment and generates tax revenue. The variables generally considered while measuring economic impact created by any industry are total revenue, number of employees, per capita wage, profit and tax revenue etc.

**Economic Impact of Gaming**

Since the casino industry facilitates gambling as its key service, gambling and the casino industry are synonymous vis-à-vis their impacts on society. However, acknowledging the fact that lotteries and pari-mutuel gambling may have social and economic impacts on society, we have not considered them here. The determinable economic impacts of the casino
industry include employment, wages and per capita income, government tax revenues, consumer benefits, and industry competition.

**Employment, Wages, and Per Capita Income**

Some of the studies on the employment impacts of casinos identify negative claims about employment and wages where they have suggested that whatever jobs are created by casinos come at the expense of other industries, so that casinos fail to produce a net increase in overall employment (Grinols & Mustard, 2001; Grinols, 2004). Others have suggested that casinos do not have any substantial impacts on average wages and casino jobs are not that exciting (Morse & Goss, 2009). Most of these published studies in this area are without substantive empirical analysis. However, there have been a few pragmatic research studies, which have suggested at least modest employment and wage benefits from casino industry expansion (Hashimoto & Fenich, 2003; Garrett, 2004). The most comprehensive research by Cotti (2008) on labor market finds positive employment and wage impacts in casino hosting counties in the US. However, most of the economic benefits are confined to the hospitality and entertainment sector of the economy.

Recent findings in this area roughly support the previous literature. Conducting a study in the context of Canada, Humphreys and Marchand (2013) find positive labor-market benefits from casinos, but that they are relatively short-lived. The positive impact on employment and earnings appears to be present only for about 5 years, with the benefits being limited to the hospitality and entertainment industries. Using data for counties in the Mid-Atlantic region, Economopoulos and Luxem (2015) also finds that positive income and employment effects in casino industry erode over time, but they also add that the economic effects are larger in urban areas and may actually be negative in rural areas.

Rather than looking specifically at employment, Hicks (2014) examined county-level income data in Indiana, a state with a well-established casino industry, from 1990 through
2008 and found a modest income growth in casino counties. However, there are small, insignificant neighboring county income declines. While Geisler and Nichols (2016) also find that income and employment rise in casino counties, in contrast to Hicks, they find neighboring counties also experience a small increase in income. Walker and Jackson (2013) expanded beyond employment and wage benefits and examined the impact of commercial casinos on overall economic growth measured by growth in per capita income. They report that indeed, casinos result in increasing per capita income and growth, and overall per capita income and economic growth are positively influenced by casino industry. Humphreys and Marchand (2013) indicated that casinos have a minor impact on generating employment in communities when high unemployment prevails prior to the casino opening. They also argued that casinos cannibalize other local hospitality and entertainment businesses and thereby the net economic impact of gaming on the destination could be muted.

**Government Tax Revenues**

Besides economic development and job creation, possibly the most important political motivation for the introduction of casino gaming, be it casinos or lotteries, is to maximize government tax revenue. Tax rates on gaming activities vary across and within countries. In the US, for example, the tax rate on casinos’ gross gaming revenues ranges from a low of around 6.75%, 9% and around 10% in Nevada, New Jersey, and South Dakota respectively to more than 50%, as in Maryland (50-62%), Pennsylvania (54%), and New York (65%) for gaming machine revenue (AGA, 2018). In the US, the casino industry faces perhaps the highest average tax rate of any industry.

Past studies on casinos and tax revenues focus on individual jurisdictions like counties or states. A more comprehensive study by Walker and Jackson (2011) was published that analyzed data from all of the US states, from 1985 to 2000. The finding was an insignificant effect of gaming on state government revenues. However, when casino impacts on tourism
and state-level economic growth are controlled for, the results could be interpreted as casinos having a modestly positive impact on state tax revenues. Recently, Nichols et al. (2015) used county-level data for 20 years (between 1987 and 2007) to examine the fiscal impact on casino-hosting counties, including tribal casinos. Substantiating literature, this study also found that casinos do not have a significant impact on per capita government spending or revenues. Overall, the literatures on casino tax revenue show that jurisdictions have adopted a wide variety of tax structures, many of which are likely inefficient, and the respective governments could improve their policies with respect to casino taxes to make their states more competitive (Philander et al. 2015; Walker & Sobel, 2016).

**Consumer Benefits**

Despite the common notion that the key economic benefits of legalized gaming relate to employment and tax revenues, economists also stress the benefits to consumers who gain utility from being able to gamble (Collins, 2003). Researchers have attempted to measure this consumer surplus and add in other benefits such as lower prices for entertainment due to increased competition (Crane, 2006) or benefits relating to reduced travel costs to casinos (Grinols, 1999). Recently, Forrest’s (2013) study on the impacts of gaming in Great Britain estimates the consumer benefits to be equivalent to £75 per household per year. He notes this is substantially greater than estimates of the social costs of gaming, although the margin is more narrow for machine gaming.

**Industry Competition**

One common concern of policymakers contemplating the introduction or expansion of legalized gaming is how the industry is likely to impact other industries. There has been a variety of papers published on how specific types of gaming affect other types of gaming (intra-industry competition, e.g., how the lottery affects casinos), as well as on how the gaming industry affects non-gaming industries (inter-industry competition, e.g., how casinos
affect nearby restaurants). Much of the work published in the 1990s argued that legalized gaming would tend to cannibalize other industries. In other words, the argument was that the revenues at casinos would come at the expense of spending on other goods and services, and consequently those other industries would suffer. Recent literature has explored the competitive effects of new entrants to the casino industry. Two studies of mature riverboat casino markets have found that new riverboat casinos do indeed cannibalize business from existing riverboats (Gallagher, 2014; Walker & Nesbit, 2014). However, the studies also find that these impacts decline rapidly with the distance between casinos. The two studies differ on the effects of casino expansion on competing casinos’ revenues. Economopoulos and Luxem (2015), studying the Mid-Atlantic States, find further evidence that casinos in different states compete with each other. Some current research attention has shifted to the relationship between online gaming and traditional (bricks and mortar) casino gaming. Philander et al. (2015) find that online gaming and land-based gaming are complementary. The study is based on self-reported gaming activity of UK respondents. Stronger evidence of complementarity is found by Philander and Fiedler (2012), identifying a positive correlation between online poker and offline gaming. As casino revenue increases so does online poker revenue, and vice versa.

Although the commercial casino industry is growing, there are very few empirical studies that report on the economic impact of casinos through measuring their performance. Some studies have attempted to identify how gaming affects housing prices (Wenz 2007), retail property values (Wiley & Walker 2011), labor markets (Cotti 2008), and state tax revenues (Walker & Jackson, 2011). What seems to be clear from these studies is the economic impact of casinos varies by market. For example, in Nevada it is difficult to imagine the casino industry not having a strong positive effect on the state’s economy. The impact is less clear in a state like Oklahoma, where the industry operates on a small scale in a
reasonably populated state. Walker and Sobel (2016) found that in the short run there are likely modest gains in employment from casinos that seem to be isolated mostly to the hospitality and entertainment industries. However, overall per capita income and economic growth are positively influenced by casino legalization and expansion (Cotti, 2008; Walker & Jackson, 2008). Current research on economic and fiscal impacts suggests that there are at least modest, short-term benefits from casino legalization and operation, through increased employment, per capita income, and tax revenues. However, these results are sensitive to time and jurisdiction (Philander et al. 2015).

**Impact of Economic Recession on Gaming**

The recession of 2008 badly affected all industries, and the hospitality and casino gaming industry was not exempted out of it. The effect of the recession led to loss of employment in the casino industry. MGM Mirage of Las Vegas, considered to be the largest gaming employer in the country, laid off 400 managers because of the economic downturn of 2008 (State Legislatures, 2009). Following the same path, 300 employees were laid off by Wynn Resorts (State Legislatures, 2009). These massive layoffs were the consequence of the declining gaming revenue during that period. Past studies have also recognized multiple factors responsible for the waning gaming revenue during the recession of 2008. These factors include real estate market foreclosures and related problems because of mortgage crisis, rising gas and food prices, widespread layoffs across different industries, and falling real estate values (Friess, 2009; Smith, 2009; White, 2009). Horvath and Paap (2012) in their study on the recession effect on gambling expenditure identified how it is related to temporary changes in income due to recession and whether income and gambling may have a long-run relationship as suggested by the permanent-income hypothesis proposed by Friedman (1957). They found that casino expenditures have substantial growth during recession.
The study of Mikesell (1994) identified a positive effect of recession on gambling. It offers an opportunity to win a jackpot, which is worth a huge amount of money for a small price. In economically difficult times people are attracted to such a tiny but real chance of winning a huge prize than in less turbulent times. Mikesell finds that lottery sales are positively correlated to the unemployment rate of the state, as they increase by around 0.17% for each 1% increase in the unemployment rate.

Recession sometimes cause an increase in gambling opportunities. During economic depression, when normal revenue growth softens, states often consider expanding their gambling operations to balance their budgets (Dadayan & Ward, 2009) to keep gambling revenues as well as taxes within the state, to reduce unemployment, and to attract tourism (Calcagno et al. 2010; Richard 2010). In a study to identify the factors behind the spread of casino gambling in 13 nations around the world, Brian Richard found that economic development needs, as measured by general unemployment rates, are associated with the casino legalization decisions by national governments (Richard, 2010). There is a high positive correlation between casino legalization decisions and the years with high unemployment.

From the above discussion, it is quite unclear how gaming activities are affected by recession; while several mechanisms suggest an increase, others imply a decrease in the same period. The limited empirical findings create more confusion. While Tenkel (1970) provides circumstantial evidence that during the Great Depression, there was an upswing in betting on horses, however past studies in the context of the Asian crisis indicate a decrease in gambling as a consequence of recession (Gu, 1999; Raab & Schwer, 2003). In this situation a micro study of whether the gaming industry of the country was significantly affected by the recession of 2008 is much needed.
Performance Measurement Models

A number of innovative methodologies and tools have been developed and used to evaluate the system performance and have been extended by various research communities, including operations research, statistics, computer science, communications and control, physics etc. (Lenzini et al., 2008). Data envelopment analysis (DEA) is one of these techniques that focuses on estimating efficiency. DEA is a multifactor productivity analysis tool that uses multiple input and output measurements in evaluating relative efficiencies of homogenous units (typically perform the same function) that are commonly described as decision making units (DMU). It optimizes individual observation for constructing the production frontier that consists of a discrete curve formed exclusively by efficient DMUs for maximizing outputs.

Charnes, Cooper and Rhodes (1978) first introduced the concept of DEA and later named it as the CCR model from their surnames to explain the construction of production frontiers and the measurement of efficiency of developed frontiers using mathematical programming. The basic assumption of this tool is that inputs are used to produce certain outputs of a firm. It also assumes constant returns to scale and decomposes overall efficiency into technical and allocative efficiencies. Over time, there have been many extensions to this model. For example, an assumption of variable returns to scale allows the decomposition of technical efficiency into pure technical efficiency and scale efficiency. Subsequently it has been observed that DEA is a popular quantitative tool to measure efficiency across the industries and has been used by numerous studies in the hospitality industry.

There has been fast and continuous growth in the field of DEA. As a result, a reasonable amount of published research has appeared on DEA, with a significant portion focused on its applications of efficiency and productivity. Using bibliometric literature analysis, the study of Lampe and Hilgers (2015) surveys DEA and Stochastic Frontier Analysis (SFA) as the most important methods to evaluate the efficiency of individual and
organizational performance. This study discussed the development of DEA and SFA research over time bunching them into different scientific disciplines. It has been observed that performance measurement research based on DEA and SFA in varied industries and sectors are heterogeneous, fragmented and still evolving regarding its structure and sub-research fields. The authors quantitatively cluster real world and make methodological contributions using document co-citation analysis in identifying valid areas of research and their impact on the scientific field. A bibliometric approach has been used to combine the judgment of a huge number of experts and analyze different groups of similar articles mapping out major research areas of DEA and SFA. Using document co-citation analysis, this study identifies that the most prevalent use of DEA method is in airports and supplier selection, and for SFA, banking and agriculture are the most influential application areas. As far as the methodological trend is concerned, Sensitivity and Fuzzy Set Theory is maximum used in DEA and Bayesian Analysis and Heterogeneity is the same for SFA. It has also been identified that research, in terms of citations, is more focused on relatively old and recent research instead of middle-aged contributions, which is a common phenomenon of a fast-developing discipline. This trend is observed for DEA and SFA independent of their age structure. Consequently, both research areas increase their rate of knowledge adoption in recent years. Therefore, both in DEA and SFA development of modern techniques has been observed. At the end, to measure and compare how much progress in terms of methodological advance or practical expansion to other fields has taken place, the study explains the adoption rate of this methodology.

Studies Using DEA in Hospitality

Morey and Dittman (1995) were the first researchers to use DEA in measuring US hotel efficiency. The uniqueness of the approach is that one can identify the practices of the most efficient general managers for example how they manage their resources, their culture and process etc. and use the same information as the basis for discussion with other general
managers. In this study authors used nine inputs and four outputs to analyze the efficiency of 54 hotels in the United States. The nine inputs used are room division expenditure, energy costs, salaries, non-salary expenses for property, salaries and related expenses for variable advertising, non-salary expenses for variable advertising, fixed market expenditures, payroll and related expenses for administrative work, and non-salary expenses for administrative work. The four outputs used are total revenue, level of service delivered, market share, and the rate of growth. In that way the researchers were able to identify the most efficient operations while providing benchmarks for less-efficient managers.

While analyzing the efficiency and in estimating the allocative, technical, pure technical levels of 48 hotels in the United States, Anderson, Fok and Scott (2000) employed DEA technique. The inputs used in this study were full-time equivalent employees, the number of rooms, total gaming-related expenses, total food and beverage expenses, and other expenses. One output used is total revenue, which is generated from rooms, gaming, food and beverages, and the other output was other revenues. This study analyzed the role of price and quantity effect in hotel efficiency. Result indicated that the US hotel industry was inefficient with a mean overall efficiency measure of approximately 42%.

Tsaur (2001) employed DEA with seven inputs and six outputs to analyze 53 international tourist hotels in Taiwan during 1996 and 1998. The seven inputs used in this study were the total operating expenses, the number of employees, the number of guest rooms, the total floor space of the catering division, the number of employees in the room division, the number of employees in the catering division, and the catering cost. The six outputs used were total operating revenues, the number of rooms occupied, average daily rate, the average production value per employee in the catering division, total operating revenues of the room division, and total operating revenues of the catering division. The
results showed that the average operating efficiency score is 0.8733. However, 71.7% of the international tourist hotels in Taiwan present relative inefficiency.

Hwang and Chang (2003) adopted data envelopment analysis (DEA) and calculated the Malmquist productivity index (MPI) to measure and analyze the managerial performance in 45 Taiwanese hotels in 1998. They also explored the cause of efficiency change during the five-year time period between 1994 and 1998. The input variables were number of full-time employees, number of guestrooms, total dimension of meal department and operating expenses whereas the output variables were room revenue, food and beverage revenue and other revenue. The outcome of this study revealed that the managerial efficiency of Taiwan’s international tourist hotels was related to the level of internationalization of the hotels. The authors also identified that there was a significant difference in efficiency change due to management styles and various sources of customers.

The research of Chiang, Tsai and Wang (2004) was aimed at using DEA to measure hotel performance under three operational styles of international tourist hotels commonly seen in Taiwan since 2000: independently owned and operated, franchise licensed, and managed by international hotel operators. The four inputs chosen by the hoteliers were hotel rooms, food and beverage capacity, number of employees, and total cost of the hotel. The three outputs were yielding index, food and beverage revenue, and miscellaneous revenue. The authors found that franchised or managed international tourist hotels performed more efficiently than the independent ones. This study also helped in strategic decision-making, precisely suggesting the suitable operational style in a highly competitive environment.

The study of Barros (2005a) calculated intra chain comparative hotel efficiency of the Portuguese state-owned chain, Pousadas and thereby examining the competitiveness of the entire chain by using DEA. It also addresses the issues in developing a framework for effective hotel assessment and rationalization. While estimating the production frontier, the
study uses cross-section data on 43 pousada hotels for the year 2001. The inputs are measured by 7 indicators: labor is measured by the number of full-time employees and by the cost of labor, capital is measured by the number of rooms, the surface area of the pousada in square meters, the book value of the premises, and the operational costs and the external costs. The study measures output by 3 indicators: sales, the number of guests and the aggregated number of nights spent. Outcome of this study suggests that the management of Pousadas must improve its follow-up inspection procedure in increasing productive efficiency, while constructing procedures so as to prevent exploitations by internal parties. Authors also suggest that the central management must expand the scope of the data obtained in the follow-up inspection to include contextual factors beyond managerial control. Authors are of the view that in order to enforce an efficient adjustment of the under-performing Pousadas, a benchmark analysis should be carried out. The regional small Pousadas operating in more remote areas of the country are disadvantaged in terms of their competitiveness. By categorizing the efficient hotels in a sample, the slacks in inputs and outputs of the inefficient hotels, the data envelopment analysis in this study protrudes as one of the most propitious method for improvement of efficiency.

Another study by Barros (2005b) attempted to benchmark the efficiency of Portugal’s public owned hotel chain Enatur using MPI, measuring productivity by decomposing productivity changes into technical change and technological (efficiency) change. This study adopted efficient frontier approach using output oriented MPI applying DEA analysis. Additionally, this research identified characteristics of productivity technology and provided a framework for the small hotel chain efficiency evaluation and rationalization of their management activities. It has also provided relative benchmarks for improving operations in low performing hotels. The result revealed that many hotels achieved efficient technical change, but no technological change and the location of the hotels is a major hindrance in
achieving optimum efficiency. Finally, increasing investment through increasing number of
rooms and decreasing number of workers could also increase the efficiency. Enatur needs
organizational governance, transparency, accountability and incentives and with these efforts,
the hotel chain may achieve efficiency in their operational activities and overcome the
deficits in technical and technological efficiency.

Wang, Hung and Shang (2006a) employed the four-stage DEA procedure to calculate
the pure managerial efficiency of 54 international tourist hotels in Taiwan. They considered
number of full-time employees, number of guest rooms, and total dining area as input
variables for this study. Outputs variables were room revenue, food and beverage revenue,
and other revenue. Their results revealed that there is no significance in pure managerial
efficiency due to differences in management style. The pure managerial style of resort hotels
is no longer more efficient than that of city hotels. The findings also included that operating
environments do affect input slacks, and the efficiency scores of traditional DEA and city
hotel is an unfavorable operating environment whereas the chain-operated hotel is a favorable
one.

Another study of Wang, Hung and Shang (2006b) used the DEA model and Tobit
regression analysis to measure the relative cost efficiency of 49 international tourist hotels
(ITH) in Taiwan in 2001. Here in this study, the authors used the single year data to analyze
the cost efficiency of ITH. The authors used five different measures, which are allocative
efficiency, scale efficiency, technical efficiency, pure technical efficiency and overall
efficiency. Four inputs were identified: number of rooms, number of full-time employees in
room departments, number of full-time employees in food and beverage departments, and
total area of food and beverage departments. Based on the four selected input variables, the
input prices in this study were the average wage rate of a full-time employee in the room
department, average room rates, average price of food and beverage operations, and average
wage rate of full-time employees in the food and beverage department. Results from the Tobit regression indicate that franchising, online transactions and proportion of foreign individual travelers are attributed to the better performance of ITHs. However, the number of years a hotel has been operating is not significantly related to any of these efficiency measures. Finally, outcome of this study indicates that the Taiwan ITHs are inefficient as the scale of operations of ITHs are too small to enable the cost-savings associated with economies of scale operations.

The study of Wang, Shang and Hung (2006) adopted the quality-incorporated MPI and applied data from the Annual Operations Report of International Tourist Hotels from 1992 to 2002 to evaluate productivity in the hotel sector. The study examined productivity changes in 29 hotels as a result of technological changes, efficiency changes, or changes in service quality. Four inputs selected were the number of guest rooms, the food and beverage capacity, the number of full-time employees, and the operating expenses. Five outputs used were room revenue, food and beverage revenue, miscellaneous revenue, the ratio of housekeeping staff per guest room, and the ratio of food and beverage staff per square meter. Their results showed that the reason for decreased efficiency changes and lowered service quality in Taiwan’s hospitality management profession was because it was not viewed as a creditable field. This mentality may be influenced by negative attitudes toward service positions in Taiwanese culture. In addition, to accommodate peak seasons, a significant number of part-time employees are hired. Such employees lack in both training and experience, which adversely impacts efficiency and service quality.

Chen (2007) estimated efficiency of Taiwan’s international tourist hotel sector by applying the stochastic cost frontier model. Primary advantage of the stochastic frontier approach over DEA is it isolates the influence of factors other than inefficient behavior, thus correcting the possible upward bias of inefficiency from the deterministic methods.
Considering this advantage, the study used the stochastic frontier approach for Taiwanese hotel efficiency measurement. A stochastic generalized Cobb–Douglas cost frontier function with three inputs, price of labor, food and beverage, and materials and one output as the total revenue of the hotels used to estimate hotel efficiency. Two control variables, room occupancy rate and the production value of unit catering space has also been considered for this study. Results reveal Taiwanese hotels are operating on an average of 80% efficiency and the factors of operation type significantly affects hotel efficiency. Additionally, the efficiency of chain hotels is higher than that of independent hotels, which reveals that the management systems of chain hotels can bring a positive impact on a hotel’s efficiency. Finally, there is no difference in efficiency between the large-scale hotels and the small-scale hotels, and there is no significant evidence that efficiency is affected by either hotel location or scale.

Sanjeev (2007) made an attempt to estimate the efficiency of Indian hotels and restaurants and identified the industry outperformer by applying DEA as an efficiency measurement tool. The study finds that 16 hotels and restaurants out of 68 samples are completely technically efficient, which implies these companies are optimally using their inputs, such as capital employed, gross fixed assets, current assets and the operating costs optimally to produce the outputs, which are profit before depreciation, interest and tax (PBDIT) and operating income. The average efficiency score for most of the companies stands around 76% which indicating the inputs are being reduced by 24% to produce the same level of outputs. Another finding of this study is size of the organization and efficiency are positively correlated, which reflects there is a direct relationship between the size and efficiency. It has also been observed that a low standard deviation of the efficiency scores exists, implying the industry is fairly competitive.

Shang, Hung and Wang (2008) applied a three-stage DEA to analyze the impact of service outsourcing on the performance of hotels. In the first stage of this study, DEA is applied
to obtain initial measures of producer efficiency using outputs and inputs data. In the second stage, stochastic frontier analysis (SFA) has been used to regress first stage efficiency measures against a set of exogenous environment variables. In the third Stage, the first stage DEA model has been run once again using the data set adjusted for both the environmental variables effect and statistical noise. In stage one of the analysis it has been observed that outsourcing hotels are more efficient than non-outsourcing hotels. However, removing the effects of exogenous factors in the next stages, the research found that no significant differences in efficiency exist owing to differences in management style. Thus, removing the impact of uncontrollable factors, the study found that service outsourcing is not the main factor in determining the efficiency of international tourist hotels in Taiwan.

In view of the exponential growth of hospitality industry in Taiwan, Hu, Chiu, Shieh and Huang (2010) considered worth paying attention to the evaluation of Taiwanese hotel operation efficiency. Using time-varying SFA approach this study estimated cost efficiency scores and identified factors of cost inefficiency for 66 ITHs of Taiwan. In this SFA model, three input and three output variables have been defined. The inputs are price of labor, price of other operation, and price of food and beverage while the outputs are room revenue, food and beverage revenue, and other operation revenue. This model also takes into account five environmental variables, including dummy variable of the hotels located in non-metropolitan area, dummy variable of chain hotels, the number of tourist guides, the minimum distance from each hotel to Taoyuan International Airport and the minimum distance from each hotel to Kaohsiung International Airport. All nominal variables are transformed into real variables in 1997 prices by considering GDP deflators. Findings of this study show that ITHs in Taiwan are on average operating at 91.15% cost efficiency and they have room to reduce their input costs by 8.85%. Furthermore, the contributions of cost efficiency in the hotel industry are significantly dependent on the structure and environmental variables (for
example chain systems, tourist guides, and international transportation) that can significantly improve the cost efficiency of international tourist hotels in Taiwan.

Pulina, Detotto, and Paba (2010) analyze the efficiency of hotels across all of the 20 regions in Italy using DEA. The main objective of the study was to test the relationship between the dimension of the firm and its efficiency, using a window DEA framework and also to provide new evidence on the efficiency of tourism infrastructure. The empirical results indicate that Sardinia can be considered as a region “falling further behind”, whereas some regions in the north and centre of Italy can be regarded as “moving ahead”. Using the island of Sardinia as a case study, approximately 150 hotels are analyzed in detail over the time period of 2002–2005. A window DEA has been used to compute technical and scale efficiencies. An efficiency comparison amongst hotels categorized by size and under which municipality it is being operated. Finally, policy implications are drawn from the practical findings and it suggests how the hotels with low efficiency scores can improve their efficiency levels.

The study of Assaf, Barros and Josiassen (2012) proposes the metafrontier concept to consider and analyzes for the environmental and technological differences between various hotel groups. The interesting feature of this concept is that the model ensures the heterogeneous hotels are compared based on one homogenous technology. The study tests the model using a secondary panel data sample of 78 Taiwanese hotels. The source of the data was Tourism Bureau of Taiwan (TBT) that conducts regular surveys of the hotel industry of Taiwan to get these data. The results clearly indicate that the size, ownership, and classification of a particular hotel have a significant impact on its efficiency. The impact of size also controls for the heterogeneity between small and large hotel groups that leads to determine their efficiency levels. Also, in terms of the relationship between efficiency and the
other two environmental variables identified in this study, namely, hotel type and hotel classification, appear to be correlated.

The study of Kim, Cho and Brymer (2013) attempted to measure the key antecedents of both service-profit chain frameworks for identifying customer and employee satisfaction, and strategic dimensions like size, customer mix etc. that influence a comprehensive hotel performance. The primary purpose of the study is to identify the primary drivers of a property’s performance. Quantitative research design using secondary data has been adopted for the study. Authors collected secondary data from an international hotel chain company for 95 hotels from 45 states and 65 cities in the United States for the year 2010, including 11 conventional hotels, 14 resorts, and 70 business hotels. Authors performed Pearson correlation analysis to identify the relationships among the independent variables, the moderating variable, and the dependent variables; a series of hierarchical multiple regressions to test the research hypotheses. Findings of this study show that customer satisfaction is a prominent driver of hotel performance; hotel size and customer mix also have significant effects on its performance; and moderating effects of hotel type on its three determinants, namely, customer satisfaction, hotel size, and customer mix and performance.

Huang, Ho and Chiu (2014) developed a modified two-stage model to evaluate productive efficiency, occupancy, and catering service effectiveness of Taiwanese ITHs. The modified two-stage model allows for multiple efficiencies to be calculated in the unique stage, and the concept of intermediate input is introduced. The model developed was tested using 58 Taiwanese international hotels. Secondary data were used to test the model and the source of the data was TBT. The results show the modified model offers a more efficient and effective approach in calculating all the efficiencies in a single DEA implementation as opposed to independent efficiency calculations.
Fernández and Becerra (2015) investigate operational efficiency drivers using DEA for 166 Spanish hotels divided into two groups - medium and upper chain scales. Authors in this study attempt to identify the drivers of efficiency that are significant in the Spanish hotel industry and what are their respective strengths, and specific factors that should be targeted to eliminate the inefficiencies and enhance the competitiveness of ineffective hotels. Secondary data from 2000 through 2009 were collected from 166 Spanish corporate hotels. Results indicated a strong relationship between levels of quality and efficiency, resort hotels were more efficient than other types of properties, and large hotels were more efficient than smaller properties. It has also been observed from the study that the effects of star rating hotels were shown in diverse findings regarding intangible investment and group membership. Midrange hotels belonging to a hotel group were more efficient, which was not true for upscale properties. Finally, the authors identified that the quality needs improvement for midrange hotels but not for upscale properties, and upscale properties had gained efficiency from investments in intangibles like information systems, while the midrange hotels did not make such investments.

Aissa and Goaied (2016) highlight the importance of operational efficiency on hotel profitability, which is a primary objective for investors. In the study, authors seek to be instrumental in identifying the determinants of successful Tunisian hotels to formulate policies in improving profitability and address the challenges. Using financial data derived from 27 hotel companies operating in Tunisia, the study reports an analysis of hotel profitability. Quantitative research design using secondary data has been adopted for the study. DEA and the Return on Assets (ROA) analysis has been used in showing managerial efficiency to be important for hotel profitability when geographical and operating contracts are considered to be constants. The outcome of the research shows that the hotel profitability depends on hotel size, indebtedness, location, crises and international attraction of the
destination. Some other identified important factors of hotel profitability are whether hotels are affiliated to an international chain, they are operating under management contract, they are avoiding the all-Inclusive system, and the education level of the managers. Finally, there is an optimal age for hotels and an optimal term period for top management in which hotels can achieve their optimum profitability level.

**Advancement of DEA Model**

In measuring the productive efficiency of international travel agencies and to benchmark regional city-wise performance of international tourism industry in China, Kao, Lin and Huang (2011) used DEA methodology. In this study, authors applied CCR, BCC (developed by and named after the researcher Banker, Charnes, and Cooper (1984)) and slacks-based measure (SBM) DEA models and the canonical analysis model to analyze the relative efficiency of international tourism development for China. Results show the inefficient cities or regions are mainly because of technical inefficiency and the inefficient host cities or regions must have to improve their efficiency through saving costs and enhancing resource usage with a wider holistic consideration of regional characteristics, economic and tourism planning policies.

While measuring productivity changes over time period, Malmquist productivity index (MPI), named after Professor Sten Malmquist, is a useful approach that applies DEA for calculating the index value (Malmquist, 1953). The purpose of MPI is to calculate the relative performance of a decision making unit (DMU) considering technology of a base period at different time economies. The efficiency measurement by Farrell (1957) and the productivity measurement by Caves et al. (1982) was combined by Färe et al. (1992) to develop MPI using DEA and divided it into two constituents a) efficiency changes measurement and b) technical changes measurement. Afterwards, Chen (2003) developed a non-radial MPI and applied to Chinese industries. Subsequently, new insights into the DEA-

The review of literature revealed certain gaps in the extant research. Particularly, casino operational efficiency appears neither to have received sufficient attention, nor has an output-oriented DEA model been used to evaluate operational efficiency and productivity. The two existing studies that applied DEA in the casino gaming industry — Lambert et al. (2010) and Huang, Lee and Lee (2012) — were conducted to measure the success of casinos in five states in the US, and the operational efficiency of Atlantic City casinos, respectively. None of these studies examined the efficiency levels of casinos at the state level and consequently their impact on the country’s economy. All the existing contextual studies inexorably overlook some very useful information on efficiency changes. Therefore, instead
of focusing on a specific state or city, a study is needed that focuses on the inter-state comparison of efficiency on the economic impact of the casino industry, thus allowing for a more comprehensive benchmarking.

Furthermore, our literature review revealed there are substantial number of studies on the performance analysis of hospitality industry, however, application of MPI in comparing different time economies in the hospitality industry is too minimal. Hwang and Chang (2003) used MPI to identify efficiency and productivity of the Taiwan hotel industry considering 45 Taiwanese hotels. Using MPI, Barros and Alves (2004) studied efficiency and productivity in the Portuguese hotel industry considering 42 Enatur hotels. Barros and Dieke (2008) applied MPI to identify the role of bootstrap on the accuracy of efficiency scores on 25 Portuguese travel agencies. Assaf and Barros (2011) analyzed the performance of Gulf hotels using MPI with a bias correction. From the literature it is also quite evident that research on casinos’ operational efficiency over time economies has not received attention in making precise decisions when planning new casino or even running the existing ones. Additionally, as our knowledge goes, none of the past studies attempted to find out the impact of the recession of 2008 on the US gaming productivity.

Therefore, this study attempts to enrich literature in two ways. First, by suggesting a model could then be used to compare state-wide efficiency measurement and thereby evaluating the economic impact of the casino industry on individual states. Second, by measuring productivity changes of casino gaming industries during pre- and post-economic recession periods, and thereby calculating MPI, which is a suitable and well-known technique available in the literature in comparing two economies (Lin, Lee, & Ho, 2011; Kao & Hwang, 2014). Moreover, for all existing studies conducted in the context of hospitality management (none of them for casino management precisely), MPI are proposed from an optimistic DEA viewpoint, where the efficiency function is minimized in getting the
optimistic frontier. None of these studies examined the MPI from a pessimistic DEA perspective by maximizing the efficiency function and subsequently getting the pessimistic frontier. Therefore, overlooking some very useful information on productivity changes may restrict us in getting a panoramic picture of it. Hence, a study measuring MPI from these two perspectives – optimistic and pessimistic is needed to explore better understanding of productivity changes over time. This dissertation provides a methodology considering both frontiers of indices. We believe, this methodology will provide a better computational technique and comprehensive view of time-based productivity changes and thereby extending the existing literature.

References


CHAPTER 3. METHODOLOGY

This chapter talks about the research methodology adopted and developed to perform this study. The purpose of this study is to measure state-wide economic impacts created by the casino industry in the US. Therefore, first, this study calculated the BCC and CCR efficiencies for the DMUs and accordingly identified the benchmarks. Subsequently, we calculated the input and output slacks using the BCC and CCR models, respectively, and calculated the input-output efficient target using both the BCC and CCR models. This study attempts to maximize the economic impact of the gaming industry on the society, therefore, an output-oriented model for both BCC and CCR has been applied here. Second, this study proposes a methodology to calculate aggregated MPI using both optimistic and pessimistic DEA perspectives to understand the average productivity changes of the DMUs over two different time economies.

DEA Models

Charnes, Cooper and Rhodes (1978) proposed the initial DEA model, CCR, built on the previous work of Ferrell (1957). It was developed as a non-parametric linear programming method to evaluate efficiency among a number of production systems categorized as DMUs. It explains the construction of production frontiers and the measurement of efficiency of developed frontiers using mathematical programming. It has become a prevalent method in management science research since its introduction. It has been widely used to evaluate various efficiencies, not only for private for-profit enterprises, but also for not-for-profit organizations including public services like hospitals (Vera & Kuntz, 2007), universities (Abbott & Doucouliagos, 2003), electric utilities (Berg, 2010), transportation (Garcia Sanchez, 2009) and for mixed cases like eco-efficiency of farming (Picazo-Tadeo, Gomez-Limon, & Reig-Martinez, 2011).
DEA constructs an efficiency frontier that represents best practices, defined as the maximum input-output combination points, which is similar to the concept of production possibility frontiers in general economics. It assigns the efficiency frontier an arbitrary score. A unit on the efficiency frontier means that it is fully efficient while a unit strictly within the frontier implies inefficiency; a linear combination of other units can produce more outputs using the same amount of inputs. The closer a DMU is located to the frontier, the more efficient it is. The scores are the ratio of radial distance of the DMU under consideration to that of the efficiency frontier (Seiford & Thrall, 1990). In this sense, DEA is a technique that evaluates each DMU’s relative efficiency by comparing it with the most efficient one within a selected pool.

There are various advantages to using the DEA method. First, unlike regression models that estimate parameters on the assumption of a specific functional form, a DEA model is a non-parametric method that does not specify any prior functional relationship between inputs and outputs. Therefore, there is neither a restriction on functional form nor a need to decide any distributional assumptions and relative weights among inputs and outputs in DEA models. Second, it simultaneously analyzes multiple inputs and outputs giving them equal weight. Third, a DEA model is not stochastic; it is, rather, deterministic, therefore, there is no statistical error in the model (Ali & Lerme, 1997). Finally, it provides relative efficiency, compared to the best observation, which we call a benchmark.

On the other hand, there are few flip sides of DEA technique. First, while giving all the inputs and outputs equal weight, if the factors actually have different weights, the results of DEA could not reflect the actual efficiency well. Second, this technique ignores the effect of exogenous variables on the operation. Third, although there is no statistical error in this model, however, if there is any noise like measurement error in the empirical dataset, then the results of DEA will also suffer from the same problem. As a result, the results of DEA are
sensitive to measurement error. Finally, DEA model provides a comparative efficiency measure among DMUs. Thus, researchers can determine which DMU is the benchmark and how much less efficient each DMU is relative to that benchmark DMU by using DEA model. This means that even the benchmark DMU could be improved upon, as the concept of a benchmark in DEA is relatively efficient rather than absolutely efficient. If one particularly efficient unit is excluded from the data, the efficiency scores of other DMUs will be higher (Ali & Lerme, 1997). Therefore, researchers always need to be cautious about the relative comparative property of DEA.

As we have discussed before, one of the most important characteristics of the DEA model is it does not require an assumption to be made about the functional structure of the model that considers the relationship between input and output variables (Hwang & Chang, 2003). DEA is more effective when the number of DMUs is equal to or more than double the number of inputs and outputs (Shirouyehzad et al. 2012). DMUs are treated as efficient when the efficiency score is equal to 1.00, otherwise they are considered inefficient (Khodabakhshi & Asgharian, 2009). So far as the BCC and CCR DEA models are concerned, the BCC model makes it possible to affect returns to scale evaluations and it envelopes the frontier more closely. It helps in estimating efficiencies when an increase or decrease in the value of input or outputs variables does not consequence in a proportional change in the outputs or inputs (Banker, Cooper, Seiford, & Zhu, 2011). In this sense, the BCC model is also called the variable returns to scale (VRS) model. On the other hand, the CCR model is designed with the assumption of constant returns to scale (CRS), which assumes that an increase in input level results in a proportionate increase in the output levels (Cooper, Seiford, & Zhu, 2011).

There are two approaches to DEA — input-oriented analysis and output-oriented analysis. While using DEA, one needs to identify an input-oriented model or an output-
oriented model. The input-oriented model answers the question of minimization of inputs and maintaining the current level of outputs, while the output-oriented model determines how to maximize outputs with the current level of inputs. The input-oriented DEA is tied to a cost minimization problem subject to fixed revenue, while the output-oriented DEA corresponds to a revenue maximization problem subject to fixed costs. The input-oriented DEA is an approach to solving the problem of how many inputs (e.g. cost) producers can reduce for the same number of production outputs (e.g. revenue). On the other hand, the output-oriented DEA is associated with the question of how many more outputs producers can produce for the same number of inputs (Emrouznejad, & Ho, 2011). As this study attempts to measure the economic impact created by the casino gaming industry, therefore, it considers output-oriented both BCC and CCR models to optimize the economic impact of the gaming industry on the society.

It is fundamentally important to specify inputs and outputs correctly for applying a DEA model. However, there is no test for the best specification. Additionally, DEA might be sensitive to the selection of input and output factors. For this reason, researchers may run a sensitivity analysis for such model (Cooper, Li, Seiford, & Zhu, 2011). Generally, the more inputs and outputs that are identified, the more DMUs have an efficiency score close to 1.00 (indicating they are efficient), because they become too specialized to be compared with other units. On the other hand, the fewer inputs and outputs that are considered, the more DMUs tend to be comparable. Additionally, to take more inputs and outputs into account, the number of DMUs should be large enough. Hence, with a small number of DMUs, researchers should not use several inputs or outputs in the DEA model. Considering the research context and its applicability, this study used i) output oriented DEA models in the first project and proposed a ii) double frontier DEA (DFDEA) model for the second project.
The Output Oriented DEA Model

Charnes, Cooper and Rhodes first introduced a DEA model known as the CCR model (Charnes et al., 1978). As we already introduced earlier, the DEA models adopts a non-parametric approach that requires data about the amount of inputs consumed by a DMU in order to convert them into outputs (Cooper, Seiford, Tone & Zhu, 2007). One distinguishing feature of DEA is that it considers each DMU as a “black box,” and hence makes no presumptions of the relationship among the variables whatsoever (Hwang & Chang, 2003). The basic output oriented DEA model can be written as:

$$\text{Max} \quad \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}}$$

s.t. \quad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1; \quad j = 1,2, \ldots, n

$$u_r, \quad v_i \geq 0; \quad r = 1,2, \ldots, s; \quad i = 1,2, \ldots, m$$

In equation (1), $x_{ij}$ and $y_{rj}$ represent the $i^{th}$ input value and $r^{th}$ output value of $j^{th}$ DMU respectively. Also, $v_i$ and $u_r$ represent the weights assigned to $i^{th}$ input and $r^{th}$ output. Moreover, $k$ represents the specific DMU whose efficiency is being evaluated.

The above model is fractional, which makes it increasingly complicated to solve. To account for this deficiency, Charnes et al. (1978) developed CCR, in which they considered the return to scale constant. The linear programming problem formulation of the CCR model is as follows:

$$\text{Min} \quad \theta - \varepsilon \left[ \sum_{i=1}^{m} S_t + \sum_{r=1}^{s} S_r \right]$$

s.t.

$$\sum_{j=1}^{n} \lambda_j y_{rj} - S_r = y_{rp}; \quad r = 1,2, \ldots, s$$
\[
\sum_{j=1}^{n} \lambda_j x_{ij} + S_i = \theta x_{ip} \; ; \; i = 1, 2, \ldots, m
\]

\[
\lambda_j \geq 0 ; \; j = 1, 2, \ldots, n
\]

\[
S_i, S_r \geq 0 ; \; i = 1, 2, \ldots, m ; \; r = 1, 2, \ldots, s
\]

However, given the fact that in a realistic scenario, this ratio is usually not constant. To overcome this problem Banker, Charnes, and Cooper (1984) introduced the BCC DEA model with variables returned to scale considering both increasing and decreasing returns to scale. The linear programming problem formulation for the BCC model is presented below:

\[
\text{Min } Z = \sum_{i=1}^{m} v_ix_{ip} + w
\]  

\[
\text{s.t. } \sum_{i=1}^{m} u_ry_{rp} = 1
\]

\[
\sum_{i=1}^{m} v_ix_{ij} - \sum_{r=1}^{s} u_ry_{rj} + w \geq 0 ; \; j = 1, 2, \ldots, n
\]

\[
U_r \geq \varepsilon ; \; r = 1, 2, \ldots, s
\]

\[
V_i \geq \varepsilon ; \; i = 1, 2, \ldots, m
\]

Considering the slacks, the modified version BCC model is as follows (Banker et al., 1984):

\[
\text{Min } \theta - \varepsilon \left[ \sum_{i=1}^{m} S_i + \sum_{r=1}^{s} S_r \right]
\]

\[
\text{s.t.}
\]

\[
\sum_{j=1}^{n} \lambda_j y_{rj} - S_r = y_{rp} ; \; r = 1, 2, \ldots, s
\]

\[
\sum_{j=1}^{n} \lambda_j x_{ij} + S_i = \theta x_{ip} ; \; i = 1, 2, \ldots, m
\]
\[
\sum_{j=1}^{n} \lambda_j = 1
\]

\[
\lambda_j \geq 0; \ j = 1, 2, \ldots, n
\]

\[
S_i, S_r \geq 0; \ i = 1, 2, \ldots, m; \ r = 1, 2, \ldots, s
\]

As seen in the above model, it is same as the “envelopment form” of the CCR model in (2) except for the fact that the condition of \(\sum_i \lambda_i = 1\) is added. However, using duality, the output-oriented BCC model can be written as:

\[
Max \ Z = \theta - \varepsilon \left[ \sum_{i=1}^{m} S_i + \sum_{r=1}^{s} S_r \right]
\]

s.t.

\[
\sum_{j=1}^{n} \lambda_j y_{rj} - S_r = \theta y_{rp}; \ r = 1, 2, \ldots, s
\]

\[
\sum_{j=1}^{n} \lambda_j x_{ij} + S_i = x_{ip}; \ i = 1, 2, \ldots, m
\]

\[
\sum_{j=1}^{n} \lambda_j = 1
\]

\[
\lambda_j \geq 0; \ j = 1, 2, \ldots, n
\]

\[
S_i, S_r \geq 0; \ i = 1, 2, \ldots, m; \ r = 1, 2, \ldots, s
\]

In equation (3) and (4), \(\theta\) is the efficiency value; \(\lambda_j\) is a reference weight associated with DMU \(j\); \(S_i\) is the slack variable of input \(i\); \(S_r\) is surplus variable of output \(r\); \(\varepsilon\) is an infinitesimal number; \(m\) is the number of input criteria; \(n\) is the number of DMUs; \(s\) is the number of output criteria; \(x_{ij}\) is the input criterion value for the \(i\)th input and the \(j\)th DMU; and \(y_{rj}\) is the output criterion value for the \(r\)th output and the \(j\)th DMU. The abovementioned CCR and BCC models have been applied in our first project.
The Double Frontier DEA Model

MPI calculates and compares the relative performance of a DMU in non-parametric framework, considering technology of a base period at different time economies. In the previous chapter, we talked about different MPI measuring methodologies available in the literature, but no attempt has been made to calculate MPI considering pessimistic DEA perspective, and thereby they overlooked some valuable perspectives of pessimistic DEA technique. The methodology we propose here considers measuring MPI from both perspectives – optimistic and pessimistic. This methodology produces different and more inclusive values than the existing optimistic based MPI calculation and provides comprehensive view of time-based productivity changes. In achieving that objective, first we separately calculate MPIs using optimistic and pessimistic DEA point of view and then we aggregate the MPIs measured from both the perspectives into an integrated MPI to understand the average productivity changes of the DMUs over two time economies. So far as returns to scale assumption is concerned, the MPI is to be calculated based on CRS method, because if it is measured using VRS, the output may be inaccurate (Grifell-Tatjé & Lovell, 1995). The efficiency change and technical change indices are obtained under the assumption that the DMUs operate according to CRS, i.e. assuming that DMUs are operating in an optimal scale.

For calculating the integrative MPI, as we considered 6-year longitudinal data available from the legalized casino gaming states of the US (between 2006 and 2012, pre- and post-recession scenarios, considering 2009 as the baseline year because the effect of the recession of 2008 on consumer spending was felt in the year 2009), therefore, MPI is the best suitable method to be used in such context as it considers the production frontiers can shift over time. The DEA model we propose here is named as double frontier DEA (DFDEA) model to calculate MPI. The reason for naming it DFDEA is because MPI has been
calculated considering both optimistic as well as pessimistic frontiers of DEA model. Once we calculated both optimistic and pessimistic MPIs, we aggregated them into an integrated MPI to show the typical time-based productivity changes of the DMUs.

Let us consider that there are \( n \) number of DMUs to be evaluated for \( m \) inputs and \( p \) outputs. At time periods \( t \) and \( (t + 1) \), the inputs and outputs of the DMUs are represented by \( x_{ij}^t \) and \( y_{rj}^t \) as well as \( x_{ij}^{t+1} \) and \( y_{rj}^{t+1} \), respectively, where \( i \) (representing number of inputs) = 1, 2, \ldots, \( m \); \( r \) (representing number of outputs) = 1, 2, \ldots, \( p \); and \( j \) (representing number of DMUs) = 1, 2, \ldots, \( n \). Solving the CCR models presented in the equation (1) and (2) and the equations (3) and (4) representing linear programming models, we can get the optimistic DEA-based MPI (Wang & Lan, 2011):

Considering input model,

\[
\text{Minimize } \theta = D_o^t(x_0^t, y_0^t) \quad \text{(1)}
\]
\[
\text{subject to } \sum_{j=1}^{n} \lambda_j x_{ij}^t \leq \theta x_{io}^t, \quad i = 1, 2, \ldots, m
\]
\[
\sum_{j=1}^{n} \lambda_j y_{rj}^t \geq \theta x_{ro}^t, \quad r = 1, 2, \ldots, p
\]
\[
\lambda_j \geq 0, \quad j = 1, 2, \ldots, n
\]

\[
\text{Minimize } \theta = D_o^{t+1}(x_0^{t+1}, y_0^{t+1}) \quad \text{(2)}
\]
\[
\text{subject to } \sum_{j=1}^{n} \lambda_j x_{ij}^t \leq \theta x_{io}^{t+1}, \quad i = 1, 2, \ldots, m
\]
\[
\sum_{j=1}^{n} \lambda_j y_{rj}^t \geq \theta x_{ro}^{t+1}, \quad r = 1, 2, \ldots, p
\]
\[
\lambda_j \geq 0, \quad j = 1, 2, \ldots, n
\]

\[
\text{Minimize } \theta = D_o^{t+1}(x_0^{t+1}, y_0^{t+1}) \quad \text{(3)}
\]
\[
\text{subject to } \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \leq \theta x_{io}^{t+1}, \quad i = 1, 2, \ldots, m
\]
\[
\sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \geq \theta x_{ro}^{t+1}, \quad r = 1, 2, \ldots, p
\]
\[
\lambda_j \geq 0, \quad j = 1, 2, \ldots, n
\]
Minimize $\theta = D_{o}^{t+1}(x_{o}^{t}, y_{o}^{t})$ \hfill (4)

subject to

$$\sum_{j=1}^{n} \lambda_{j} x_{ij}^{t+1} \leq \theta x_{io}^{t}, \quad i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} \lambda_{j} y_{rj}^{t+1} \geq \theta x_{ro}^{t}, \quad r = 1,2,\ldots,p$$

$$\lambda_{j} \geq 0, \quad j = 1,2,\ldots,n,$$

Where $\theta$ indicates a score to represent the DEA efficiency, $\lambda_{j}$ is an intensity variable for DMU that is to be used to construct the best practice frontier, distance functions $D_{o}^{t}(x_{o}^{t}, y_{o}^{t})$ and $D_{o}^{t+1}(x_{o}^{t+1}, y_{o}^{t+1})$ measure the optimistic efficiencies of DMU_{o} (o \in \{1, 2, \ldots, n\}) in time $t$ and $t+1$, respectively. $D_{o}^{t}(x_{o}^{t+1}, y_{o}^{t+1})$ measures optimistic efficiency in time $t+1$ using the technical efficiency of time period $t$, it is named as the DMU’s growth index (Sueyoshi, 1998), and $D_{o}^{t+1}(x_{o}^{t}, y_{o}^{t})$ optimistically calculates the efficiency of DMU_{o} in time period $t$ using the technical efficiency of time period $t+1$.

In view of the above optimistic efficiencies, the following optimistic DEA-based MPI can be proposed:

$$\text{MPI}_{o} \text{ (optimistic)} = \left[ \frac{D_{o}^{t}(x_{o}^{t+1}, y_{o}^{t+1})}{D_{o}^{t}(x_{o}^{t}, y_{o}^{t})} \cdot \frac{D_{o}^{t+1}(x_{o}^{t+1}, y_{o}^{t+1})}{D_{o}^{t+1}(x_{o}^{t}, y_{o}^{t})} \right]^{1/2} \hfill (5)$$

it computes the productivity change of DMU_{o} from time $t$ to $t+1$. As per Färe et al. (1992), MP{Io(optimistic)} > 1 indicates increase in productivity, MP{Io(optimistic)} = 1 signifies that productivity is unaffected, and MP{Io(optimistic)} < 1 indicates decreasing productivity.

In excluding the assumption of Caves et al. (1982) that $D_{o}^{t}(x_{o}^{t}, y_{o}^{t})$ and $D_{o}^{t+1}(x_{o}^{t+1}, y_{o}^{t+1})$ should have unit value, Färe et al. (1992) divided the optimistic MPI presented in the equation (5) into two parts:
The first part is
\[ \text{OEC}_o = \frac{D_t^{t+1}(x_o^t, y_o^t)}{D_t(x_o^t, y_o^t)} \] (7)

It calculates the optimistic efficiency change (OEC) for DMUo. When OEC > 1, the optimistic efficiency of DMUo will be enhanced, and OEC < 1, the same for DMUo will be reduced. The second part is

\[ \text{OTC}_o = \left[ \frac{D_t^{t+1}(x_o^t, y_o^t)}{D_t(x_o^t, y_o^t)} \cdot \frac{D_t^{t+1}(x_o^t, y_o^{t+1})}{D_t^{t+1}(x_o^t, y_o^t)} \right]^{1/2} \] (8)

It calculates the optimistic technical change (OTC) of DMUo from time t to t + 1.

**MPI from the Pessimistic DEA**

When the efficiencies are computed from the pessimistic perspective, it is being called as pessimistic efficiencies. The following pessimistic DEA model quantifies the pessimistic efficiency of DMUo with respect to other DMUs (Wang, Chin & Yang, 2007; Wang & Chin, 2009):

Minimize \( \varphi_o = \sum_{r=1}^{p} \mu_r y_{ro} \) subject to

\[ \sum_{i=1}^{m} \omega_i x_{io} = 1 \]

\[ \sum_{r=1}^{p} \mu_r y_{rj} - \sum_{i=1}^{m} \omega_i x_{ij} \geq 0, \quad j = 1,2,\ldots,n \]

\[ \mu_r, \omega_i \geq 0, \quad r = 1, 2, \ldots, p; \quad i = 1,2, \ldots, m \]

The dual of this linear programming model can be written as

Maximize \( \varphi_o \) subject to

\[ \sum_{j=1}^{n} x_{ij}\lambda_j \geq \varphi_o x_{io} \quad i = 1,2,\ldots,m \]

\[ \sum_{j=1}^{n} y_{rj}\lambda_j \leq y_{ro} \quad r = 1,2,\ldots,p \]

\[ \lambda_j \geq 0, \quad j = 1, 2, \ldots, n. \]
Therefore, 
Maximize \( \varphi = D^t_o(x^t_0, y^t_0) \) \hspace{1cm} (11) 
subject to 
\[ \sum_{j=1}^{n} \lambda_j x^t_{ij} \geq \varphi x^t_{io}, \quad i = 1, 2, \ldots, m, \]
\[ \sum_{j=1}^{n} \lambda_j y^t_{rj} \leq y^t_{ro}, \quad r = 1, 2, \ldots, p, \]
\[ \lambda_j \geq 0, \quad j = 1, 2, \ldots, n, \]

Maximize \( \varphi = D^{t+1}_o(x^{t+1}_0, y^{t+1}_0) \) \hspace{1cm} (12) 
subject to 
\[ \sum_{j=1}^{n} \lambda_j x^{t+1}_{ij} \geq \varphi x^{t+1}_{io}, \quad i = 1, 2, \ldots, m, \]
\[ \sum_{j=1}^{n} \lambda_j y^{t+1}_{rj} \leq y^{t+1}_{ro}, \quad r = 1, 2, \ldots, p, \]
\[ \lambda_j \geq 0, \quad j = 1, 2, \ldots, n, \]

Maximize \( \varphi = D^{t+1}_o(x^{t+1}_0, y^{t+1}_0) \) \hspace{1cm} (13) 
subject to 
\[ \sum_{j=1}^{n} \lambda_j x^{t+1}_{ij} \geq \varphi x^{t+1}_{io}, \quad i = 1, 2, \ldots, m, \]
\[ \sum_{j=1}^{n} \lambda_j y^{t+1}_{rj} \leq y^{t+1}_{ro}, \quad r = 1, 2, \ldots, p, \]
\[ \lambda_j \geq 0, \quad j = 1, 2, \ldots, n, \]

Maximize \( \varphi = D^{t+1}_o(x^t_0, y^t_0) \) \hspace{1cm} (14) 
subject to 
\[ \sum_{j=1}^{n} \lambda_j x^{t+1}_{ij} \geq \varphi x^t_{io}, \quad i = 1, 2, \ldots, m \]
\[ \sum_{j=1}^{n} \lambda_j y^{t+1}_{rj} \leq y^t_{ro}, \quad r = 1, 2, \ldots, p \]
\[ \lambda_j \geq 0, \quad j = 1, 2, \ldots, n \]

Where \( D^t_o(x^t_0, y^t_0) \) and \( D^{t+1}_o(x^{t+1}_0, y^{t+1}_0) \) computes the pessimistic efficiencies of DMU_0 (o \( \in \) \{1, 2, ..., n\}) in time t and t+1, correspondingly, \( D^t_o(x^{t+1}_0, y^{t+1}_0) \) calculates its pessimistic efficiency in time t+1 using the technical efficiency of time t, and \( D^{t+1}_o(x^t_0, y^t_0) \) calculates the pessimistic efficiency of DMU_0 for the time t using the technical efficiency of time t+1.

Therefore, the productivity changes from time t to t+1 can be represented as follows:
\[\text{MPI}_o(\text{pessimistic}) = \left[ \frac{D^o_t(x^t_{o+1}, y^t_{o+1})}{D^o_t(x^t_o, y^t_o)} \cdot \frac{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)}{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)} \right]^{1/2} \quad (15)\]

It is the geometric mean of two productivity indices measured from pessimistic DEA perspective. Considering the fact that proposed by Färe et al. (1992), MPIo(\text{pessimistic}) > 1 indicates increase in productivity, MPIo(\text{pessimistic}) = 1 signifies that productivity is unaffected, and MPIo(\text{pessimistic}) < 1 specifies decreasing productivity.

As discussed above, the pessimistic DEA-based MPI can also be divided into two elements:

\[\text{MPI}_o(\text{pessimistic}) = \left[ \frac{D^o_t(x^t_{o+1}, y^t_{o+1})}{D^o_t(x^t_o, y^t_o)} \cdot \frac{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)}{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)} \right]^{1/2} \]

\[= \frac{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)}{D^t_o(x^t_o, y^t_o)} \cdot \frac{D^t_o(x^t_o, y^t_o)}{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)} \quad (16)\]

The first part is,

\[PEC_o = \frac{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)}{D^t_o(x^t_o, y^t_o)} \quad (17)\]

\(PEC_o\) measures the pessimistic efficiency change (PEC) for DMUo. PEC > 1 implies that there is an improvement in the optimistic efficiency of DMUo, while OEC < 1 signifies the opposite i.e., optimistic efficiency of DMUo has reduced. The second part is

\[PTC_o = \left[ \frac{D^t_o(x^t_o, y^t_o)}{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)} \cdot \frac{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)}{D^{t+1}_o(x^{t+1}_o, y^{t+1}_o)} \right]^{1/2} \quad (18)\]

which calculates the pessimistic technical change (PTC) of DMUo from time t to t + 1.

**MPI Aggregation**

The MPI values calculated from both DEA perspectives are not equal, rather they are significantly different that may lead to different result as well as different conclusion.

Therefore, it is very important to aggregate them into a combined MPI value to come up to a
final result. As discussed before in the equation (5), the geometric mean of the optimistic and the pessimistic DEA based MPI values can give an integrated MPI value. Geometric mean can reflect criticality of individual productivity value because the overall measure takes zero value when any of the productivities takes the value zero irrespective of the other value. Therefore,

\[ \text{MPIo (DFDEA)} = [\text{MPIo(optimistic)} \cdot \text{MPIo(pessimistic)}]^{1/2}, \]  

(19)

It is the typical productivity change of DMUo from the optimistic as well as the pessimistic DEA perspectives and can be further decomposed into

\[ \text{MPIo(DFDEA)} = [(\text{OECo} \cdot \text{OTCo}) (\text{PECo} \cdot \text{PTCo})]^{1/2} \]

\[ = [\text{OECo} \cdot \text{PECo}]^{1/2} \cdot [\text{OTCo} \cdot \text{PTCo}]^{1/2} \]

\[ = \text{ECo} \cdot \text{TCo}, \]  

(20)

where \( \text{ECo} = [\text{OECo} \cdot \text{PECo}]^{1/2} \) and \( \text{TCo} = [\text{OTCo} \cdot \text{PTCo}]^{1/2} \) respectively represents the average efficiency change of DMUo as well as technical change for the time \( t \) and \( t + 1 \). As the MPI value delineated in the equation (19), it is the combination of the MPI values calculated from the optimistic as well as the pessimistic DEA, therefore it is being called as the MPI value based on double frontier DEA. It is more inclusive and pragmatic than the traditional optimistic MPI value and it can precisely produce the time based productivity changes of the DMUs.

**The Variables**

For measuring economic impact of the casino industry, generally costs and consumption are used as some of the important input variables (Marshall & Shortle, 2005). To measure the economic impact created by the casino industry, we need to see how efficiently it boosts employment and generates tax revenue. The variables generally considered for measuring economic impact are gross revenue, number of employees
employed, per capita wage, profit, and tax revenue from the industry. Reagan and Gitter (2007) also argued that increasing income and increased employment opportunities are the most direct consequences of gaming facilities. Gross revenue is defined as the amount a gaming operation earns before taxes, salaries and other expenses are paid (AGA, 2016). It is equivalent to sales, or in other words, it is consumers’ total spending in casinos. Usually, this gross revenue is a prime variable for use as an output; any study which has an interest in a particular industry’s profit efficiency would naturally select gross revenue as one of its measures of outputs. However, other studies consider outputs as number of employees, per capita wage and tax revenues rather than how well the casino industry makes a profit (Tsaur, 2001; Reynolds & Biel, 2007).

Some other relevant economic variables might be earned money or revenue per se and physical size of the facility (Chen, 2009). For earned money in casinos, Tanford and Lucas (2011) use slot coin-in and table drops, which indicate cash drops for all table games and total dollar amounts wagered in all gaming machines, respectively. Eisendrath et al. (2008) support the argument that slot coin-in is the purest gaming volume indicator and is considered as the only accurate volume indicator recorded by casinos. For physical size, the area of the casino, number of slot machines, and number of table games are the prime candidates. Lee and Back (2006) enumerate six items for positive casino impact: 1) investment and business, 2) tourist spending, 3) standard of living, 4) tax revenues, 5) employment opportunities, and 6) personal income. However, excluding tourist spending and tax revenues, the rest of the variables are subjective in nature and they have a direct effect on the society because they are used to support the local economy and to redistribute wealth.

Although slot coin-in and table drops would be the best input variables, there is not enough public access to these figures for all the casinos of the 24 states to be able to measure them accurately. Therefore, based on the above discussion, for our first project, total casino
area (in sq. ft), number of slot machines and gross gaming revenue have been chosen as inputs. In this study, gross gaming revenue has been used as a proxy variable for earned money. As the past study suggested that increasing income and better employment opportunities are the most direct consequences of gaming industry on the society (Reagan & Gitter, 2007), therefore, output variables considered for the first project are — number of casino employees, average per capita wage of casino employees and gaming tax revenue.

For the second project undertaken in this study the inputs are aggregated as — number of employees employed in the casinos, and total employee wages paid in that state; while the outputs have been identified as — gross gaming revenue, and gaming tax revenue from each considered state. Being a service industry, casinos are labor intensive. Generally, labor cost for hospitality industry can account for around 33% of total revenues, and 43% of all operating expenses (Jones & Lockwood, 2002). Thus, it is not surprising that most studies on hotel efficiency have included number of employees and their wages as inputs (Barros & Dieke, 2008; Assaf & Barros, 2011; Huang, Lee & Lee, 2012). Our selected outputs are common for measuring efficiencies in hospitality studies (Barros, 2005a, 2005b; Reynolds & Biel, 2007; Chen, 2007; Assaf & Barros, 2011; Huang, Lee & Lee, 2012). The input and output factors considered in the proposed model are the state-wide summation of all the casino properties’ inputs and outputs.

**Data Collection**

A quantitative research design involving secondary data has been applied in this study for measuring state-wide economic impacts created by the casinos in the US. This study obtained gaming data from AGA surveys of the commercial casino industry in the US. Instead of studying all casino places including Native American casinos, this study considers data from those gaming facilities that AGA recognizes as legal and currently operating casinos. The sample (here called as DMUs) contained all states of the US where casino
gaming is legalized and whose data are available on AGA database. The first project identified 24 states of the US with the input-output gaming data available for the year 2015. The second project considered 6-year longitudinal gaming data available from 12 states of the US between 2006 and 2012. Assuming that the effect of the recession of 2008 on consumer spending was felt in the year 2009 (Bor et al., 2013), the pre-recession years considered here in this study are 2006, 2007 and 2008, and post-recession years are 2010, 2011 and 2012.

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CHAPTER 4. UNVEILING NEW PERSPECTIVES WHILE MEASURING ECONOMIC IMPACT OF THE US CASINO GAMING INDUSTRY: A DATA ENVELOPMENT ANALYSIS

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Abstract

The purpose of this study is to empirically evaluate the economic impact created by casinos and whether their operational efficiency translates into improved quality of life for the communities in which they operate. A quantitative research design has been applied to this study in measuring state-wide economic impacts created by the casinos in the US. The output-oriented BCC (Banker, Charnes, and Cooper) and CCR (Charnes, Cooper and Rhodes) data envelopment analysis (DEA) model has been adopted for the analysis of secondary data publicly available from American Gaming Association’s (AGA) yearly published report. Based on available data, among twenty-one US states considered in this study, thirteen states are efficient and less efficient states’ casinos could improve the level of their employment in creating more community impact. Casino practitioners may apply this benchmark research model to evaluate their casinos’ economic impact especially in terms of generating more employment for the society.

Keywords: Casino gaming, operational efficiency, economic impact, output oriented data envelopment analysis (DEA), benchmarking, gaming revenue.

Introduction

The operational efficiency of the hospitality industry - measured through various financial indicators such as cost-volume-profit index, revenues, sales receipts, and lodging index (Wassenaar & Stafford, 1991; Baker & Riley, 1994) - is a much-studied phenomenon. These financial indicators, however, portray output performance only, leaving an incomplete
picture for researchers and practitioners. A great deal of past research used efficiency measures to evaluate the performance of the hospitality industry, considering both multiple inputs consumed, and multiple outputs generated. Some of them, such as Anderson et al. (1999), Hu et al. (2010), have introduced the parametric efficiency measure to estimate efficiency using an econometric model. Non-parametric efficiency measurement methods like data envelopment analysis (DEA) are frequently applied in examining the hospitality industry (Barros & Dieke, 2008; Aissa & Goaied, 2016; Ben Aissa et al., 2016), however very few such studies exist examining the operational performance of casinos specifically.

The casino gaming industry has long had an established economic presence in the United States (Garrett & Nichols, 2008); the industry is currently one of the fastest-growing industries in the country (American Gaming Association, 2016). As the industry grows, more and more state policy makers have come to view legal casinos as a way to lighten their fiscal stress (Lambert, Srinivasan, Dufrene & Min, 2010). Consequently, an increasing number of states have legalized casino gaming in one form or another. Numerous studies have shown gaming to be a significant driver of tourism and economic development (Chhabra & Gursoy, 2007; Walker, 2013). In response to the growing importance of this industry, many researchers have turned their attention to examining the economic impacts of gaming (Walker & Sobel, 2016; Forrest, 2007). However, in spite of the growing importance of legalized gaming, very few researchers have been able to publish empirical research on it (Walker, 2009). There are a number of reasons behind this lack of research; one of the most important is an absence of quality data on the impact of casinos on host communities (Zheng & Hung, 2012). Industry-sponsored studies existing in the literature conclude that local and state economies and communities can benefit immensely from the gaming industry (Andersen, 1996; Walker, 2013). In the context of the economic benefits, local governments have taken a favorable view of casinos (Ham, Brown & Jang, 2004). However, there has always been a
concern that industry-sponsored studies are susceptible to bias, as those studies are largely conducted by the state governments that supported gaming legalization in the first place. Furthermore, these studies primarily focus on taxes paid to the government and employees hired by the casino industry and ignore other factors that have an impact on quality of life within a community.

Properly measuring financial performance is an important issue for casino managers, not only for the businesses themselves, but it is also important for casino operators, because of political considerations, to generate optimum economic impact for the communities in which they operate. Studies that unequivocally explain the effects of the variables directly produced by the gaming industry in creating economic impact are difficult to find. While literature has identified the social (Walker & Sobel, 2016) and economic (Walker & Jackson, 2011; Philander et al. 2015) impacts of the industry in isolation, no study has been conducted to understand the combined (socioeconomic) phenomena of the country’s gaming industry.

Nearly all such studies fail to explicitly consider or explain the moderating effects of the intermediate variables, produced by the casino industry, responsible for creating economic impact. Further, these studies generally assume that all casinos efficiently manage their properties, a somewhat rash assumption. Too, there is a fundamental disconnect in play: the measures that matter to casino operators when it comes to operational efficiency are not the things that matter to local and state governments. Casino operators are concerned with maximizing profit while governments are concerned with maximizing tax revenues, employment, and other quality of life measures, and the one does not necessarily lead to the other. Therefore, the main objective of this study is to use the data envelopment analysis (DEA) technique conceptualized by Charnes, Cooper and Rhodes (CCR) (1978) to empirically evaluate the economic impact of these intermediate variables and determine first,
whether casinos are operating efficiently, and second, whether casino operational efficiency translates into improved quality of life for the communities in which they operate.

**Literature Review**

**Studies on Socioeconomic Impact of Casino**

Casino gaming has been a part of American culture since colonial times, but the development of casino gaming has long been a controversial topic for the public (Rose, 1995; Walker, 2013). Public attitudes toward gambling activities were based on both community benefits and individual interests (Nichols, Tosun, & Yang, 2015). Lee, Kim, and Kang (2003) found that casino gaming can promote local tourism; thus, the tourism industry brings more personal income and increases employment opportunities in a given community. Researchers have found that the gaming industry can stimulate local economies and help resist economic recession (Giacopassi, Nichols, & Stitt, 1999; Nicholos et al., 2015). In addition, the casino industry could create new purchasing power, and increase new tax revenues (Long, 1995; Humphreys & Marchand, 2013). However, opponents argue that casino gaming can harm a local economy by bringing with it various social problems like organized crime, gaming addiction, bankruptcy, family dissension etc., and these problems could threaten security in local communities (Hsu 2000a; Lee & Back, 2006; Koo, Rosentraub, & Horn, 2007). Another study by Humphreys and Marchand (2013) indicated that casinos have only a minor impact on employment in communities with high unemployment prior to the casino opening, and it cannibalizes other local hospitality and entertainment venues so the net economic impact of gaming on the destination could be muted. Walker and Sobel (2016) noted that the social impacts of gambling are multifaceted, generally negative in nature, and are often attributed to disordered gamblers. Some of the negative social effects may include bankruptcy, crime, personal health issues, family problems, etc. However, excluding drunk driving, recent studies have found that there is a weak correlation between casinos and both crime and
bankruptcies (Hsu 2000a; Stitt et al., 2005; Lee & Back, 2006; Koo, Rosentraub, & Horn, 2007). The social impact of casinos is more difficult to measure than the economic impact as they are abstract in nature. However, Lee and Back (2006) specified six positive social factors associated with casinos: investment and business, tourist spending, standard of living, tax revenues, employment opportunities, and finally personal income.

The economic impacts of casinos analysed in the literature include local employment and wages, government tax revenues, consumer benefits, industry competition, and economic development. Although the commercial casino industry is growing, there are very few empirical studies that report on the economic impact of casinos. Some studies have attempted to identify how gaming affects housing prices (Wenz 2007), retail property values (Wiley and Walker 2011), labor markets (Cotti 2008), and state tax revenues (Walker & Jackson, 2011). What seems to be clear from these studies is that the economic impact of casinos varies by market. For example, in Nevada it is difficult to imagine the casino industry not having a strong positive effect on the state’s economy. The impact is less clear in a state like Oklahoma, where the industry operates on a small scale in a reasonably populated state. Walker and Sobel (2016) found that in the short run there are likely modest gains in employment from casinos that seem to be isolated mostly to the hospitality and entertainment industries. However, overall per capita income and economic growth are positively influenced by casino legalization and expansion (Cotti, 2008; Walker & Jackson, 2008). The literature on government tax revenue shows that jurisdictions have adopted a wide variety of tax structures, many of which are likely inefficient (Philander et al. 2015; Walker & Sobel, 2016). Current research on economic and fiscal impacts suggests that there are at least modest, short-run benefits from casino legalization and operation, through increased employment, per capita income, and tax revenues. However, these results are sensitive to time and jurisdiction (Philander et al. 2015).
Studies Using DEA on Hospitality and Casino

A number of innovative methodologies and tools have been used to evaluate system performance having been developed, as well as extended by, various research communities; including operations research, statistics, computer science, communications and control, physics etc. (Lenzini et al., 2008). Data envelopment analysis (DEA) is one of these innovative techniques that focuses on estimating efficiency. DEA is a multifactor productivity analysis tool that uses multiple input and output measurements in evaluating relative efficiencies. Charnes, Cooper and Rhodes (1978) first introduced the concept of DEA and later named as the CCR model from their surnames (Charnes, Cooper and Rhodes) to explain the construction of production frontiers and the measurement of efficiency of developed frontiers using mathematical programming. The basic assumption of this tool is that inputs are used to produce certain outputs of a firm. It also assumes constant returns to scale and decomposes overall efficiency into technical and allocative efficiencies. Over time there have been many extensions to this model. For example, an assumption of variable returns to scale allows the decomposition of technical efficiency into pure technical efficiency and scale efficiency. Subsequently it has been observed that DEA is a popular quantitative tool to measure efficiency across the industries and has been used by numerous studies in the hospitality industry (presented in the Table 1).

Purpose of the Study

The review of literature revealed certain gaps in the extant research. Particularly, casino operational efficiency appears not to have received sufficient attention, nor has an output-oriented DEA model been used to evaluate operational efficiency and productivity. Further, that model could then be used to compare those measures of efficiency to state-by-state measures to evaluate the economic impact of the industry in the individual states. The two existing studies that applied DEA in the casino gaming industry, by Lambert et al. (2010)
and by Huang et al. (2012), were conducted to measure, respectively, the success of casinos in five states and the operational efficiency of Atlantic City casinos. None of these studies examined the efficiency levels of casinos at the state level and consequently their impact on the country’s economy. All the existing contextual studies inexorably overlook some very useful information on efficiency changes. Therefore, instead of focusing on a specific state or city, this study focuses on the inter-state comparison of efficiency on the economic impact of the casino industry, thus allowing for a more comprehensive benchmarking. Secondly, only a few studies exist on the adoption of DEA for evaluating casino performance and identifying useful benchmarks for efficiency improvement in less efficient casinos. Also, this study uses the DEA method to calculate benchmarks in dealing with intermediate variables generated in the casino gaming industry. Finally, as no study has used DEA to evaluate casino performance and identify constructive benchmarks for performance improvement in less efficient casinos, this study aims to extend the method in this area.

**Methodology**

A quantitative research design has been applied to this study in measuring state-wide economic impacts created by the casinos in the US. This study adopted the DEA model for quantitative analysis. Secondary data, publicly available from American Gaming Association’s (AGA) yearly published report have been used for the DEA analysis. Here, we first calculated the states’ CCR and BCC (named after Banker, Charnes, and Cooper) efficiency and found the benchmarks. Afterwards, we calculate the input and output slacks using the BCC and CCR models, respectively. Finally, we calculated the efficient input-output target using BCC and CCR model. This study considered the input-output data for the year 2015.

Charnes, Cooper and Rhodes (1978) proposed the initial DEA model (henceforth CCR model) built on the previous work of Ferrell (1957). It was developed as a non-
parametric linear programming method to evaluate efficiency among a number of production systems called decision making units (DMUs). It explains the construction of production frontiers and the measurement of efficiency of developed frontiers using mathematical programming. It has become a prevalent method in operations and management research since its introduction. It has been widely used to evaluate various efficiencies, not only for private for-profit enterprises, but for not-for-profit organizations including public services like hospitals (Vera & Kuntz, 2007), universities (Abbott & Doucouliagos, 2003), electric utilities (Berg, 2010), transportation (Garcia Sanchez, 2009) and for mixed cases like eco-efficiency of farming (Picazo-Tadeo, Gomez-Limon, & Reig-Martinez, 2011).

The Model

Charnes, Cooper and Rhodes first introduced a DEA model known as the CCR model (Charnes et al., 1978). DEA is a non-parametric approach that only requires data about the amount of inputs which are consumed by a decision-making units (DMUs) in order to convert them into output amounts (Cooper et al., 2007). One distinguishing feature of DEA is that it considers each DMU as a “black box,” and hence makes no presumptions of the relationship among the variables whatsoever (Hwang and Chang, 2003). The basic DEA model is presented below:

\[
\begin{align*}
\text{Max} & \quad \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}} \\
\text{s.t.} & \quad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1; \quad j = 1, 2, \ldots, n \\
& \quad u_r, \ v_i \geq 0; \quad r = 1, 2, \ldots, s; \quad i = 1, 2, \ldots, m
\end{align*}
\]

In equation (1), \(x_{ij}\) and \(y_{ij}\) represent the \(i^{th}\) input value and \(r^{th}\) output value of \(j^{th}\) DMU respectively. Also, \(v_i\) and \(u_r\) represent the weights assigned to \(i^{th}\) input and \(r^{th}\) output. Moreover, \(k\) represents the specific DMU whose efficiency is being evaluated.
The above model is fractional, which makes it increasingly complicated to solve. To account for this deficiency, Charnes et al. (1978) developed CCR, in which they considered the return to scale constant. The linear programming problem formulation of the CCR model is as follows:

\[
\begin{align*}
    \text{Min} & \quad \theta - \varepsilon \left[ \sum_{i=1}^{m} S_i + \sum_{r=1}^{s} S_r \right] \\
    \text{s.t.} & \quad \sum_{j=1}^{n} \lambda_j y_{rj} - S_r = y_{rp} ; \quad r = 1,2,\ldots,s \\
    & \quad \sum_{j=1}^{n} \lambda_j x_{ij} + S_i = \theta x_{ip} ; \quad i = 1,2,\ldots,m \\
    & \quad \lambda_j \geq 0 ; \quad j = 1,2,\ldots,n \\
    & \quad S_i, S_r \geq 0 ; \quad i = 1,2,\ldots,m ; \quad r = 1,2,\ldots,s
\end{align*}
\] (2)

However, given the fact that in a real scenario, this ratio is usually not constant, Banker, Charnes, and Cooper (BCC) (1984) introduced the BCC model with variables returned to scale. The BCC model in linear programming problem formulation is presented in the following:

\[
\begin{align*}
    \text{Min} & \quad Z = \sum_{i=1}^{m} v_i x_{ip} + w \\
    \text{s.t.} & \quad \sum_{i=1}^{m} u_r y_{rp} = 1 \\
    & \quad \sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} + w \geq 0 ; \quad j = 1,2,\ldots,n \\
    & \quad U_r \geq \varepsilon ; \quad r = 1,2,\ldots,s
\end{align*}
\] (3)
\[ V_i \geq \varepsilon; \quad i = 1, 2, \ldots, m \]

Considering slacks, the modified version BCC model is as follows (Banker et al., 1984):

\[
\text{Min} \quad \theta - \varepsilon \left[ \sum_{i=1}^{m} S_i + \sum_{r=1}^{s} S_r \right]
\]

s.t.

\[
\sum_{j=1}^{n} \lambda_j y_{rf} - S_r = y_{rp}; \quad r = 1, 2, \ldots, s
\]

\[
\sum_{j=1}^{n} \lambda_j x_{ij} + S_i = \theta x_{ip}; \quad i = 1, 2, \ldots, m
\]

\[
\sum_{j=1}^{n} \lambda_j = 1
\]

\[ \lambda_j \geq 0; \quad j = 1, 2, \ldots, n \]

\[ S_i, S_r \geq 0; \quad i = 1, 2, \ldots, m; \quad r = 1, 2, \ldots, s \]

As seen in the above model, it is same as the “envelopment form” of the CCR model in (2) except for the fact that the condition of \( \sum \lambda_i = 1 \) is added. However, using duality, the output-oriented BCC model can be written as:

\[
\text{Max} \quad Z = \theta - \varepsilon \left[ \sum_{i=1}^{m} S_i + \sum_{r=1}^{s} S_r \right]
\]

s.t.

\[
\sum_{j=1}^{n} \lambda_j y_{rf} - S_r = \theta y_{rp}; \quad r = 1, 2, \ldots, s
\]

\[
\sum_{j=1}^{n} \lambda_j x_{ij} + S_i = x_{ip}; \quad i = 1, 2, \ldots, m
\]

\[
\sum_{j=1}^{n} \lambda_j = 1
\]
In equation (3) and (4), \( \lambda_j \) is a reference weight associated with DMU \( j \); \( S_i \) is the slack variable of input \( i \); \( S_r \) is surplus variable of output \( r \); \( \varepsilon \) is an infinitesimal number; \( m \) is the number of input criteria; \( n \) is the number of DMUs; \( s \) is the number of output criteria; \( x_{ij} \) is the input criterion value for the \( i \)th input and the \( j \)th DMU; and \( y_{rj} \) is the output criterion value for the \( r \)th output and the \( j \)th DMU.

One of the main advantages of DEA is that it is not necessary to make an assumption about the functional structure of the model that considers the relationship between input and output variables (Hwang and Chang, 2003). DEA is more effective when the number of DMUs is equal or more than the double number of inputs and outputs (Shirouyehzad et al. 2012). DMUs are treated as efficient when the efficiency score is equal to 1.00, otherwise they are considered inefficient (Khodabakhshi & Asgharian, 2009). The BCC model makes it possible to affect returns to scale evaluations. In this sense, the BCC model is also called the variable returns to scale (VRS) model while the CCR model is called as the constant returns to scale (CRS) model. While using DEA, one needs to identify an input-oriented model or an output-oriented model. The input-oriented model answers the question of minimization in inputs maintaining the current level of outputs; while the output-oriented model determines how to maximize output with the current level of inputs. As this study attempts to measure the economic impact of the casino gaming industry, therefore, it considers output-oriented both BCC and CCR model to maximize the economic impact of the gaming industry on the society.

**Data Analysis and Results**

This study investigates the economic impact of the casino industry in each state and focuses on how efficiently the casino industry boosts employment and generates tax revenue.
Therefore, every state’s casino industry is considered to be something that produces an economic effect. Thus, the entire casino industry within each state will be a DMU in the model. This study deals with aggregated data, and the input factors and outputs in the model are the state-wise sum of all the casino properties’ inputs and outputs. As inputs, this study selects three factors – number of slot machines used, square feet of gaming space and gross revenue. So far as the output is concerned, this study chooses three factors – number of employees, wage per employee and gaming tax revenue from casino industry in each state.

While measuring economic impact costs and consumption are generally used as input variables (Marshall & Shortle, 2005). Gross revenue is defined as the amount a gaming operation earns before taxes, salaries and other expenses are paid (American Gaming Association, 2016). It is equivalent to sales, or in other words, it is consumers’ total spending in casinos. Usually, this gross revenue is a prime variable for use as an output; any study which has an interest in a particular industry’s profit efficiency would naturally select gross revenue as one of its measures of outputs. However, in our study, we focus on how efficiently the casino industry affects the economies of the respective states, so we consider outputs as number of employees, per capita wage and tax revenue as opposed to industry profitability.

We consider relevant inputs to be earned money, physical size of the casino, and so on. For earned money, Tanford and Lucas (2011) use slot coin-in and table drops, which indicate cash drops for all table games and total dollar amounts wagered in all gaming machines, respectively. Eisendrath, Bernhard, Lucas and Murphy (2008) support the argument that slot coin-in is the purest gaming volume indicator and is considered the only accurate volume indicator recorded by casinos. Although slot coin-in and table drops would be the best input variables, there is not enough public access to these figures for all the casinos of the twenty-four states to be able to measure them accurately. Therefore, this study uses gross revenue as a proxy variable for earned money. For physical size, the area of
casino, number of slot machines, and number of table games are the prime candidates. In addition, we have only twenty-four DMUs in this study, which means fewer inputs and outputs are needed in order to prevent the case that too many DMUs become efficient. Hence, this study chose casino area and number of slot machines as inputs.

Output measurements reflect the economic factors of greatest concern and comprehensive efficiency (Sigala 2004). Lee and Back (2006) enumerate six items for positive casino social impact: 1) investment and business, 2) tourist spending, 3) standard of living, 4) tax revenues, 5) employment opportunities, and 6) personal income. Tax revenues have a direct effect on the society as they are used to support the local economy and to redistribute wealth. Meanwhile, Reagan and Gitter (2007) argued that increasing income and increased employment opportunities are the most direct consequences of gaming facilities. In this sense, output measurement in this study is comprised of the number of casino employees, the average wage and gaming tax revenue.

This study considers a total of twenty-four states among all states of the US, where casino gaming is legalized and whose basic information is provided in the American Gaming Association (AGA) website are used as DMUs.\(^1\) All data needed for this study were collected from each state’s Gaming Commission website and the American Gaming Association website. Instead of studying all casino places including Indian casinos, this study uses only casinos that the AGA recognizes as current operating casinos. The performance of the casinos used in this study is for the year 2015. On an average, the casino industry in each state produced gross revenues of approximately $1.6 billion with 1.3 million square feet of gaming area while creating about 14600 jobs and providing an average wage of $37500 (Table 2).

\(^1\) They are Colorado, Delaware, Florida, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Michigan, Mississippi, Missouri, Nevada, New Jersey, New Mexico, New York, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota and West Virginia. Originally, the total number of states which are informed in AGA website is 24 (2015). However, one of them –Massachusetts is excluded due to a lack of information needed in this study.
For the DEA analysis, we used the DEAFrontier software package to calculate all efficiency scores.

**Results**

Table 3 shows four different types of efficiency scores and rankings from the BCC model. Among twenty-four states, thirteen states – Delaware, Illinois, Louisiana, Maine, Massachusetts, Nevada, New Jersey, New York, Oklahoma, Pennsylvania, Rhode Island, South Dakota and West Virginia – are efficient with respect to the BCC model while Michigan is the least efficient. This means, considering variable return to scale (in other words, an increase in inputs does not result in a proportional change in the outputs), output efficiency of the state Michigan is the lowest of the states measured.

**Slack Analysis**

Slacks can be used to determine efficiency targets and to show how to improve efficiency. Ozcan (2008) explicated, “Slacks represent only the leftover portions of inefficiencies; after proportional reductions in inputs or outputs, if a DMU cannot reach the efficiency frontier (to its efficiency target), slacks are needed to push the DMU to the frontier.” Slacks in input factors indicate the amount of unnecessary expenditure and they can be reduced without any loss of efficiency. Output slacks mean the amount by which the outputs could increase through reducing inputs to the minimum level that is required for the original outputs. In this study, non-zero slacks exist in BCC and CCR model outputs (See Table 4 and 5). Considering the output-oriented BCC model, Colorado has non-zero slack in slot machine (among the inputs) and per capita wage (among outputs). It can minimize 184 slot machines and boost average wage by $13,850 through more efficient management. In case of Florida, it can minimize 17,188 slot machines and casino area by 993,260 sq. ft. and boost average wage by $6,014 through more efficient management. Kansas and New Mexico have positive output slacks in gaming tax revenue, which means that through management
efficiency there is a scope of improving gaming tax revenue for these states. From all these values it is evident that there is a scope of improving economic impact of the gaming industry towards the society through increased number of employees, wages and gaming tax revenue.

For efficiency targets, slack is also used as one of the components of the target. In the output-oriented BCC model, the efficient input and output targets are calculated using efficiency scores. In this research, Table 6 and 7 show efficient input and output targets using output-oriented BBC and CCR model. For example, the BCC model suggests that with the given inputs, outputs i.e. number of employees, per capita wages and gaming tax revenue can be increased by 9.3%, 20.2% and 12.4% respectively whereas among the inputs slot machines and casino area should be reduced by 9.5% and 6.8% respectively to achieve optimal technical efficiency. Florida is the least efficient in the use of slot machine and casino area inputs, requiring a decrease of 67.1% and 69.1% respectively in order to be optimally efficient. Considering the outputs, Mississippi should increase number of employees by 34.4%, Maryland needs to augment per capita wages by 76.75% and Kansas needs to boost gaming tax revenue by 73.5% to achieve optimal efficiency. The CCR model outputs (Table 7) are also in line with the BCC results. It suggests that with the given inputs, outputs i.e. number of employees, per capita wages and gaming tax revenue can be increased by 15.6%, 118.4% and 15.6% respectively whereas among the inputs slot machines and casino area should be reduced by 3.8% and 2.3% respectively to achieve optimal technical efficiency.

**Discussion and Industry Implications**

Using DEA, this paper calculates the efficiency of the casinos in various states of the United States. The results demonstrate that the economic impact created by more than the half of the states where casino gaming is legalized is significant, however, it has failed to fulfill its promise in a number of ways. Unlike a static framework, the method utilized in this study yields a comparison of a state’s casino industry - considered to be a DMU - to its own
past performance as well as the performance of the other states. This method helps identify the benchmark of casino economic impact by comparing all DMUs to provide a comprehensive index for measuring their overall efficiency. By performing DEA analysis on slot machines, square feet of gaming space, gross revenue, number of employees, wage per employee and gaming tax revenue of each state’s casino, this research model was designed to determine the optimal benchmark for commercial casinos. Moreover, the methodology in itself can represent an important tool for policy makers, through the identification of a number of policy strategies that appear to be crucial for the evolution of the impending casino deliberation.

By applying DEA, this study was able to integrate different variables to analyze the quantitative data. Since all data used are numeric, the results do not involve a static comparison or lists of taxes paid and/or employees hired by the casino industry. The results are therefore more objective and accurate than previous studies. DEA helps identify the benchmark of casino economic impact by comparing all decision-making units to provide a comprehensive index for measuring their overall efficiency.

A total of twenty-four states across the United States whose basic information is provided in the AGA website were studied. These casinos’ performances were evaluated by the calculated efficiency scores and thus comparatively more efficient states’ casinos could be identified. Among twenty-one states, thirteen states are efficient with respect to the output-oriented BCC model. Also, the findings of this study suggest that less efficient states’ casinos could improve the level of their employment as indicated in the slacks identified from our model. In addition, casino practitioners may apply this benchmark research model to evaluate their casinos’ economic impact especially in terms of employment, that way they can show policy makers that the positive societal impact created by the industry. Finally, the findings provide decision makers with a better understanding of how exactly the casinos affect their
community and how to enhance their existing casinos’ productivity through the identification of the non-benchmarked inputs and output variables and thereby identifying the scopes for improvement. For instance, many businesses cease to exist because of their operational inefficiency (Frei, 2006; Bandyopadhayay, 2006), one reason for this is inefficient use of labor. On the other hand, inefficient use of labor might also be an indication of too few employees. Such a business must necessarily experience service problems. Increasing employment in those states, like Mississippi, which have slack in employment is recommended.

The key point to remember is that, while this research identifies ways in which casino performance could be improved to optimize benefits to local economies, casino operators are primarily concerned with optimizing benefits for their shareholders. If we assume that casino companies are already operating in ways that best serve their interests, the difference between the ways in which they operate and the ways that might achieve greater benefits for the communities in which they exist should be the subject of discussion for both the operators and the state and local governments in the affected areas.

The findings of this study need to be taken cautiously because of the limitation in the choice of the input and output variables due to the lack of accessibility to useful data. Therefore, authors suggest that future research could further explore efficiency improvements in the casino industry by using more input and output variables if accessible, or by extending the number of the various states. For example, if researchers can access the information related to coin-in and/or table drop revenue in states where it is not publicly available, the study will be able to provide better managerial analysis. Nevertheless, the methodology in itself can represent an important tool for policy makers, through the identification of relevant policy strategies that appear to be crucial for the realization of the future casino debate.
References


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<th>Outputs</th>
<th>Prices</th>
<th>Contribution</th>
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Table 2
Summary of the input and output data used in DEA

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<th>States</th>
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<th>Total casino sq. ft.</th>
<th>Gross Gaming Rev.(in mn)</th>
<th>No. of Employees</th>
<th>Per capita Wage</th>
<th>Gaming Tax Rev.(in mn)</th>
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Table 3
State-wise DEA efficiency scores

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<th>Rankings of BCC Index</th>
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### Table 4

*Slacks in output oriented BCC model*

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<th>No. of Employees</th>
<th>Per capita Wage</th>
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Table 7
Efficient target in the output-oriented CCR model

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CHAPTER 5. MEASURING CASINO ECONOMIC PERFORMANCE USING THE MALMQUIST INDEX: A DOUBLE FRONTIER DATA ENVELOPMENT ANALYSIS

Asit Bandyopadhyay, Somak Dutta and Tianshu Zheng

Iowa State University

Modified from a manuscript to be submitted to Tourism Management Perspectives

Abstract

Whether the operational efficiency of the US casinos creates positive economic impact thereby improving quality of life for the communities in which they operate, is a contemporary question. As a consequence, techniques to evaluate the performances of casinos is gradually gaining popularity. In this research paper, we propose to calculate Malmquist productivity index (MPI) for state-wise US casinos using double frontier data envelopment analysis (DFDEA) where we use both optimistic and pessimistic frontiers data envelopment analysis (DEA). As MPI calculates productivity changes over time, we attempt to see the effect of the great recession on the casino industry performance and hence considered 2009 as baseline year and calculated the performance of the casinos during pre (2006-08) and post-recession (2010-12) years. Compared with existing DEA benchmark models, our results suggest that DFDEA-based MPI reveals the productivity changes of decision making units (DMUs) over time more precisely and comprehensively than traditional MPI.

Keywords: Double frontier data envelopment analysis (DFDEA), Malmquist Productivity Index (MPI), Casino tourism, operational performance, efficiency measurement, gaming socioeconomic impact, benchmarking, casino gaming revenue.

Introduction

The US has always been the world’s famous international tourist destination in terms of tourism receipts. As per the world bank data, in 2016, the US earned US$244.7 billion which is much ahead of Spain ($60.6 billion), followed by Great Britain ($55.6 billion) and
France ($50.9 billion). The famous US cities like Las Vegas, Los Angeles, New York thrive with tourists all around the year. The prominent natural attractions of the country include the Yellowstone National Park, Niagara Falls, Grand Canyon, Hawaiian beaches, Alaskan mountains and many more. According to the World Travel and Tourism Council (WTTC, 2017), in the US, the travel and tourism industry directly contributes 2.7% of the country’s GDP and the industry has a total contribution (which includes direct, induced and indirect) 8.1% of the country’s GDP. Tourism industry is among the top five industries generating the maximum employment opportunities in the United States and it is the third highest growing industry (after health care & social assistance and educational services) in the last 10 years of the country (Bureau of Labor Statistics, 2017). Figure 1 presents top seven international tourism receipts (in US$) countries in the world during 1995-2015.

*Figure 1. International tourism receipts (in US$)*

The casino gaming industry is one of the key sectors in tourism and it has established its strong economic influence in the United States (Garrett & Nichols, 2008). At the same time, the industry has been one of the strongest growing industries in the country (American Gaming Association, 2016). As the industry is growing, more and more state policy makers have come to view legal casinos as a way to lighten their fiscal stress (Lambert, Srinivasan, Dufrene & Min, 2010). Consequently, increasing number of states have legalized casino gaming in one form or the other and has been accepted as one the most significant drivers of increased tourism and economic development (Chhabra & Gursoy, 2007; Walker, 2013). In accordance to the growing importance of this industry, many researchers have turned their attention to examining the economic impacts of gaming (Walker & Sobel, 2016; Forrest, 2007). However, in spite of the growing importance of legalized gaming, very limited researchers have been able to publish empirical research on it (Walker, 2009). There are number of reasons behind it. One of the most important reason is quality data on the impact
of casinos on host communities is hard to get (Zheng & Hung, 2012). Industry-sponsored studies strongly suggest that local and state economies and community can be benefitted immensely from the gambling industry (Andersen, 1996; Walker, 2013). To that end, local governments have taken a favorable view of casinos in the context of economic benefits (Ham, Brown & Jang, 2004). However, the industry-sponsored studies are open to criticism on the ground that they are susceptible to bias and having conflict of interest, as those studies are conducted by the institutions that supported gaming legalization in the first place (Wohl & Wood 2015). Furthermore, these studies primarily talk about taxes paid to the government and employees hired by the casino industry and ignore other factors that have direct impact on quality of life within a community.

The operational efficiency of casino industry has drawn much attention where the same has been measured through various financial indicators such as cost-volume-profit index, lodging index, revenues, and sales receipts (Fay, Rhoads, & Rosenblatt, 1971; Jagels & Coltman, 1978; Van Doren & Gustke, 1982; Kimes, 1989; Wassenaar & Stafford, 1991; Baker & Riley, 1994). However, these financial indicators only portray output performance. Large number of past researches uses efficiency measures to evaluate the performance of hospitality industry while considering both multiple inputs consumed and multiple outputs generated. Some of them (Anderson et al. 1999; Chen, 2007; Hu et al., 2010) have introduced the parametric efficiency measure to estimate the efficiency of hospitality industry using econometrics models. Non-parametric efficiency measurement method like data envelopment analysis (DEA), are frequently applied techniques in the hotel industry. However, very limited study exists in the literature that talks about the operational performance of casinos precisely.

Therefore, in this study, we attempt to rationally evaluate the state-wise efficiency measurement of the gaming industry. Additionally, we want to see the impact of Great
Recession of 2008 on the US gaming industry. Past studies identify the effect of recession on hospitality industry as a whole, however, they did not see its impact specifically on the US gaming industry (Spencer, 2008; Pearce, 2012; Poudyai, Paudel, & Tarrant, 2013; Zheng, Farrish, & Wang, 2013). As we did not find any comprehensive methodology in calculating gaming industry performance over a period of time, therefore, this study proposes a new methodology by developing an annually aggregated productivity index that summarizes the productivity changes before and after recession year 2009 (considering 2009 as baseline year). The findings will help policy makers to identify the economic impact of casinos and framing strategies to aggressively promote their business in local markets especially during recession to improve their business at the time of economic downturn. That way regional customers can experience similar environment with significantly less spending which otherwise they have to travel to big destination. It will also help casino industry practitioners in developing and/or running their existing casinos in a strategic manner. Additionally, this study aims to contribute to the present literature by providing a method of analysis.

**Literature Review**

**Studies on Casino Gaming**

Casino gaming has been a part of American culture since colonial times, but the development of casino gaming has long been a controversial topic for the public (Rose, 1995; Walker, 2013). Public attitudes toward gambling activities were based on both community benefits and individual interests (Nichols, Tosun, & Yang, 2015). Lee, Kim, and Kang (2003) found that casino gaming can promote local tourism; thus, the tourism industry brings more personal income and increases employment opportunities in a given community. Researchers have found that the gaming industry can stimulate local economies and help resist economic recession (Giacopassi, Nichols, & Stitt, 1999; Nicholos et al., 2015). In addition, the casino industry could create new purchasing power, and increase new tax revenues (Long, 1995; Humphreys & Marchand, 2013). However, opponents argue that casino gaming can harm a
local economy by bringing with it various social problems like organized crime, gaming addiction, bankruptcy, family dissension etc. and these problems could threaten security in local communities (Hsu 2000b; Stitt, Nichols, & Giacopassi, 2005; Lee & Back, 2006; Koo, Rosentraub, & Horn, 2007). Another study by Humphreys and Marchand (2013) indicated that casinos have minor impact on employment in communities with high unemployment prior to the casino opening, and it cannibalizes other local hospitality and entertainment venues so the net economic impact of gaming on the destination could be muted. Walker and Sobel (2016) identified that the social impacts of gambling are multifaceted which are generally negative in nature. Some of the negative social effects may include crime, bankruptcy, personal health and family related issues etc. However, excluding drunk driving, past studies identified that there is weak correlation between casinos and both crime and bankruptcies (Hsu 2000a; Stitt et al., 2005; Lee & Back, 2006; Koo, Rosentraub, & Horn, 2007). The economic impacts of casinos are much easier to measure than social impacts as the latter is abstract in nature. In this context, Lee and Back (2006) specified six items of casino’s positive social impact which are investment and business, tourist spending, standard of living, tax revenues, employment opportunities, and finally personal income.

The economic influences of casinos as analyzed in the literature include tax revenues generated for the government, local employment and wages, economic development etc. Although commercial casino industry is growing, but there are very few empirical studies that reports the economic impacts of casinos. Few studies have attempted to identify how gaming affects housing prices (Wenz 2007), retail property values (Wiley & Walker 2011), labor markets (Cotti 2008), tax revenues of state (Walker & Jackson 2011). What seems to be clear from these studies is that the economic impacts of casinos may vary by market. For example, in state like Nevada, it is difficult to imagine the casino industry not having a strong positive effect on the state’s economy. But the impact is less clear in a state like Oklahoma,
where the industry operates in a small scale in a reasonably populated state. Walker and Sobel (2016) in their study found that in the short run there are likely modest gains in employment from casinos that mostly confined to the hospitality and entertainment industries. However, from the past studies it is very clear that inclusive per capita income and economic growth are positively correlated with casino legalization and expansion (Cotti, 2008; Walker & Jackson, 2008). The literature on government tax revenue shows that authorities have adopted a wide variety of tax structures and some of them are seems to be inefficient. Most recent research on casino economic and fiscal impacts proposes modest, short-run benefits from casino legalization and operation by better employment, income and tax revenue generation (Philander et al. 2015).

Studies on Hospitality and Casino Performance Measurement

In the literature, there are number of innovative methodologies and tools for evaluating system performance that have been developed as well as extended by various research communities; including operations research, statistics, computer science, communications and control, physics etc. (Lenzini et al, 2008). Data envelopment analysis (DEA) is one of them that focus on estimating efficiency. DEA is a multifactor, productivity analysis tool that uses multiple input and output measurements in evaluating relative efficiencies. Charnes, Cooper and Rhodes (1978) first introduced the concept of DEA and later named as the CCR model to explain the construction of production frontiers and the measurement of efficiency of developed frontiers using mathematical programming. The basic assumption of this tool is inputs are being used to produce certain outputs of a firm. It also assumes constant returns to scale and decomposes overall efficiency into technical and allocative efficiencies. Eventually, there have been many extensions to this model, for example, an assumption of variable returns to scale allows the decomposition of technical efficiency into pure technical efficiency and scale efficiency. Subsequently it has been
observed that DEA is a popular quantitative tool to measure efficiency across the industries and has been used by numerous studies in the hospitality industry (summarized in Table 1).

The review of literature revealed there are substantial number of studies on the performance analysis of hospitality industry however, application of Malmquist productivity index (MPI) in the hospitality industry is too minimal. Hwang and Chang (2003) used MPI to identify efficiency and productivity of Taiwan hotel industry considering 45 Taiwanese hotels. Using MPI, Barros and Alves (2004) studied efficiency and productivity in Portuguese hotel industry considering 42 Enatur hotels. Barros and Dieke (2008) applied MPI to identify role of bootstrap on the accuracy of efficiency scores on 25 Portuguese travel agencies. Assaf and Barros (2011) analysed the performance of Gulf hotels using MPI with a bias correction. From the literature it is also quite evident that research on casinos’ operational efficiency should receive more attention to make suitable decisions when planning new casino construction or even running existing one. Additionally, as our knowledge goes, none of the past studies attempted to find out the impact of great recession on the productivity US gaming industry. Therefore, this study attempts to calculate productivity changes of casino gaming industries during pre- and post-economic recession periods, calculating MPI is a suitable technique which is well-known in the literature in comparing two economies (Lin, Lee, & Ho, 2011; Kao & Hwang, 2014). All the existing studies in hospitality management, MPI are proposed from optimistic DEA (through minimizing the efficiency function and thereby getting the optimistic frontier) viewpoint and none of these studies examined the MPI from pessimistic DEA perspective where we maximize the efficiency function and subsequently getting the pessimistic frontier. Therefore, inexorably overlooking some very useful information on productivity changes is not at all a good idea. Above all, measuring MPI from these two perspectives – optimistic and pessimistic, does not produces similar values as the existing ones and they are not at all compliment to each other. Calculating MPI
from these two perspectives can provide a better computational technique and comprehensive view of time-based productivity changes. Therefore, this study aims to extend the existing literature in multiple ways. Firstly, we introduce a novel methodology to calculate the MPI. Secondly, we focus on identifying efficiency changes during pre and post-recession periods to see the impact of recession on gaming economy. Our methodology considers both optimistic and pessimistic frontiers of DEA method, called as double frontier data envelopment analysis (DFDEA) method to measure both optimistic and pessimistic efficiency change and technical change and subsequently calculating the index. These measures have interestingly important interpretations which we have discussed in the results section.

Methodology

DEA and Development of MPI

Charnes, Cooper and Rhodes (1978) proposed the initial DEA model built on the earlier work of Ferrell (1957). It was developed as a non-parametric linear programming method to evaluate efficiency among a number of production systems called decision making units (DMUs). It explains the construction of production frontiers and the measurement of efficiency of developed frontiers using mathematical programming. It has become a prevalent method in operations and management research since its introduction. The basic assumption of this tool is inputs are being used to produce certain outputs of a firm. It also assumes constant returns to scale and decomposes overall efficiency into technical and allocative efficiencies. DEA constructs an efficiency frontier which represents best practices, defined as the maximum input-output combination points, as a similar concept with production possibility frontiers in general economics. It assigns the efficiency frontier an arbitrary score. A unit on the efficiency frontier means that it is fully efficient while a unit strictly within the frontier implies inefficiency; that a linear combination of other units can produce more outputs using same amount of inputs. The closer a DMU is located to the frontier, the more
efficient it is. The scores mean the ratio of radial distance of the DMU under consideration to that of the efficiency frontier. In this sense, DEA is a technique that evaluates each DMU’s relative efficiency by comparing it with the most efficient DMU within a selected DMUs pool.

Looking at the advantages of using the DEA method, firstly unlike regression models that estimate parameters on the assumption of a specific functional form, a DEA model is a non-parametric method that does not specify any prior functional relation between inputs and outputs. So, there is neither a restriction on functional form nor a need to decide any distributional assumptions and relative weights among inputs and outputs in DEA models. DEA gives all the inputs and outputs equal weight. Therefore, if the factors actually have different weights, the results of DEA could not reflect the actual efficiency well. Also, a DEA model is not stochastic rather deterministic, so that there is no statistical error in the model. However, if there is any noise like measurement error in empirical dataset, then the results of DEA will suffer from the same problem. Especially, the results of DEA are sensitive to measurement error. Second, DEA provides a comparative efficiency measure among DMUs. Thus, researchers can determine which DMU is the benchmark and how much less efficient each DMU is relative to that benchmark DMU by using DEA. This means that even the benchmark DMU could be improved upon because the concept of a benchmark in DEA is “relatively efficient” rather than “absolutely efficient.” If one particularly efficient unit is excluded from the data, the efficiency scores of other DMUs will be higher. Therefore, researchers always need to be cautious about the relative comparison property of DEA.

It is fundamentally important to specify inputs and outputs correctly for applying a DEA model. However, there is no test for the best specification. Additionally, DEA might be possibly sensitive to the selection of input and output factors. For this reason, researchers may run a sensitive test for their model. Generally, the more inputs and outputs are identified,
the more DMUs have an efficiency score of one because they become too specialized to be compared with other units. On the other hand, the fewer inputs and outputs are considered, the more DMUs tend to be comparable. Additionally, to take more inputs and outputs into account, the number of DMUs should be large enough. Hence, with small number of DMUs, researchers should not use several inputs or outputs in DEA.

Malmquist productivity index (MPI) is a useful approach for productivity measurement in DEA, named after Professor Malmquist, as it is based on his ideas (Malmquist, 1953). The purpose of MPI is to calculate the performance of a decision making unit (DMU) considering technology of a base period at different periods of time. The efficiency measurement by Farrell (1957) and the productivity measurement by Caves et al. (1982) was combined by Färe et al. (1992) to develop MPI using DEA and divided it into two constituents a) efficiency changes measurement and b) technical changes measurement. Afterwards, Chen (2003) developed a non-radial MPI and applied to Chinese industries. Subsequently, new insights into the DEA-based MPI proposed by Chen and Ali (2004), developing a geometric mean based component simplified the results. A global MPI proposed by Pastor and Lovell (2005) considering the technology defined by the DMUs. Zelenyuk (2006) developed MPI based on the efficiency scores of Farrell. Yu (2007) proposed a MPI that measures the change of capacity productivity as well as input productivity. In 2009, Lo and Lu recommended a slacks based measure (SBM)-MPI model for estimating the productivity of financial holding companies of Taiwan. Kao (2010) extended the work of Pastor and Lovell (2005) and developed a weight-based DEA model of the global MPI to identify changes in the pre and post-reorganization productivity of Taiwan forests. Wang and Lan (2011) proposed double frontiers technique for calculating MPI for the productivity analysis of Chinese industrial economy. Tohidi et al. (2012) proposed a global cost MPI, which is circular, and it gives a single measure of productivity change. Zhang and Choi

Although all of the above research papers talk about different MPI methodologies, but no attempt has been made to calculate MPI considering pessimistic DEA perspective and thereby they overlooked some valuable perspective of pessimistic DEA technique. The methodology we proposed in this paper considers measuring MPI from both perspectives – optimistic and pessimistic. This methodology produces different and inclusive values than the existing optimistic based MPI calculation and provides comprehensive view of time-based productivity changes. Therefore, in this paper, first we separately calculate MPIs using optimistic and pessimistic DEA point of view and then we aggregate the MPIs measured from both the perspectives into an integrated MPI to understand the average productivity changes of the DMUs over two time economies. So far as returns to scale assumption is concerned, the MPI is to be calculated based on constant return to scale (CRS) method, because if it is measured using variable return to scale (VRS), the output maybe inaccurate (Grifell-Tatjé & Lovell, 1995). The efficiency change and technical change indices are obtained under the assumption that the DMUs operates according to CRS, i.e. assuming that DMUs are operating in an optimal scale.

The Model

This study considers quantitative research design using secondary data. It measures Malmquist productivity index which is a productivity measure and can be decomposed into technical change and efficiency change using DFDEA. Here, initially calculation of the MPI from the optimistic as well as pessimistic DEA perspective has been performed. Afterwards,
aggregation of the MPIs calculated from the optimistic and the pessimistic DEA perspective into an integrated MPI has been done to show the typical time-based productivity changes of the DMUs. This study considered 6-year longitudinal data of gaming (between 2006 and 2012, pre and post-recession scenario, considering 2009 as baseline year), therefore MPI is the best suitable method to be used in such context as MPI considers the production frontiers can shift over time.

Let us consider that there are \( n \) number of DMUs to be evaluated for \( m \) inputs and \( p \) outputs. At time periods \( t \) and \( (t + 1) \), the inputs and outputs of the DMUs are represented by \( x_{ij}^t \) and \( y_{rj}^t \) as well as \( x_{ij}^{t+1} \) and \( y_{rj}^{t+1} \), respectively, where \( i \) (representing number of inputs) = 1, 2, \ldots, \( m \); \( r \) (representing number of outputs) = 1, 2, \ldots, \( p \); and \( j \) (representing number of DMUs) = 1, 2, \ldots, \( n \). Solving the CCR models presented in the equation (1) and (2) and the equations (3) and (4) representing linear programming models, we can get the optimistic DEA-based MPI (Wang & Lan, 2011):

Considering input model,

Minimize \( \theta = D_o^t(x_o^t, y_o^t) \)
subject to

\[
\sum_{j=1}^{n} \lambda_j x_{ij}^t \leq \theta x_{io}^t, \quad i = 1, 2, \ldots, m
\]
\[
\sum_{j=1}^{n} \lambda_j y_{rj}^t \geq \theta x_{ro}^t, \quad r = 1, 2, \ldots, p
\]
\[
\lambda_j \geq 0, \quad j = 1, 2, \ldots, n
\]

Minimize \( \theta = D_o^{t+1}(x_o^{t+1}, y_o^{t+1}) \)
subject to

\[
\sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \leq \theta x_{io}^{t+1}, \quad i = 1, 2, \ldots, m
\]
\[
\sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \geq \theta x_{ro}^{t+1}, \quad r = 1, 2, \ldots, p
\]
\[
\lambda_j \geq 0, \quad j = 1, 2, \ldots, n
\]

Minimize \( \theta = D_o^{t+1}(x_o^{t+1}, y_o^{t+1}) \)
subject to

\[
\sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \leq \theta x_{io}^{t+1}, \quad i = 1, 2, \ldots, m
\]
\[
\sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \geq \theta x_{r0}^{t+1}, \quad r = 1, 2, \ldots, p \\
\lambda_j \geq 0, \quad j = 1, 2, \ldots, n
\]

Minimize \( \theta = D_0^{t+1}(x_o^t, y_o^t) \) \hspace{1cm} \( (4) \)
subject to
\[
\sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \leq \theta x_{i0}^t, \quad i = 1, 2, \ldots, m \\
\sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \geq \theta x_{ro}^t, \quad r = 1, 2, \ldots, p \\
\lambda_j \geq 0, \quad j = 1, 2, \ldots, n,
\]

Where \( \theta \) indicates a score to represent the DEA efficiency, \( \lambda_j \) is an intensity variable for DMU that is to be used to construct the best practice frontier, distance functions \( D_0(x_o^t, y_o^t) \) and \( D_0^{t+1}(x_o^{t+1}, y_o^{t+1}) \) measure the optimistic efficiencies of DMU \( o \in \{1, 2, \ldots, n\} \) in time \( t \) and \( t+1 \), respectively, \( D_0^t(x_o^{t+1}, y_o^{t+1}) \) measures optimistic efficiency in time \( t+1 \) using the technical efficiency of time period \( t \), it is named as the DMU’s growth index (Sueyoshi, 1998), and \( D_0^{t+1}(x_o^t, y_o^t) \) optimistically calculates the efficiency of DMU \( o \) in time period \( t \) using the technical efficiency of time period \( t+1 \).

In view of the above optimistic efficiencies, the following optimistic DEA-based MPI can be proposed:

\[
\text{MPI}_o \text{ (optimistic)} = \left[ \frac{D_0^t(x_o^{t+1}, y_o^{t+1}) \cdot D_0^{t+1}(x_o^{t+1}, y_o^{t+1})}{D_0^t(x_o^t, y_o^t) \cdot D_0^{t+1}(x_o^t, y_o^t)} \right]^{1/2} \hspace{1cm} (5)
\]

it computes the productivity change of DMU \( o \) from time \( t \) to \( t+1 \). As per Färe et al. (1992), \( \text{MPI}_o \text{ (optimistic)} > 1 \) indicates increase in productivity, \( \text{MPI}_o \text{ (optimistic)} = 1 \) signifies that productivity is unaffected, and \( \text{MPI}_o \text{ (optimistic)} < 1 \) indicates decreasing productivity.

In excluding the assumption of Caves et al. (1982) that \( D_0^t(x_o^t, y_o^t) \) and \( D_0^{t+1}(x_o^{t+1}, y_o^{t+1}) \) should have unit value, Färe et al. (1992) divided the optimistic MPI presented in the equation (5) into two parts:
MPI \text{(optimistic)} = \left[ \frac{D_0(t+1)(x_{0o}^{t+1}, y_{0o}^{t+1})}{D_0(t)(x_{0o}^{t}, y_{0o}^{t})} \cdot \frac{D_0(t+1)(x_{0o}^{t+1}, y_{0o}^{t+1})}{D_0(t)(x_{0o}^{t}, y_{0o}^{t})} \right]^{1/2} = \frac{D_0(t+1)(x_{0o}^{t+1}, y_{0o}^{t+1})}{D_0(t)(x_{0o}^{t}, y_{0o}^{t})} \cdot \frac{D_0(t+1)(x_{0o}^{t+1}, y_{0o}^{t+1})}{D_0(t)(x_{0o}^{t}, y_{0o}^{t})}^{1/2} \quad (6)

The first part is
\[
\text{OEC}_o = \frac{D_0(t+1)(x_{0o}^{t+1}, y_{0o}^{t+1})}{D_0(t)(x_{0o}^{t}, y_{0o}^{t})}
\]

It calculates the optimistic efficiency change (OEC) for DMUo. When OEC > 1, the optimistic efficiency of DMUo will be enhanced, and OEC < 1, the same for DMUo will be reduced. The second part is
\[
\text{OTC}_o = \left[ \frac{D_0(t)(x_{0o}^{t}, y_{0o}^{t})}{D_0(t+1)(x_{0o}^{t}, y_{0o}^{t})} \cdot \frac{D_0(t+1)(x_{0o}^{t+1}, y_{0o}^{t+1})}{D_0(t)(x_{0o}^{t}, y_{0o}^{t})} \right]^{1/2}
\]

It calculates the optimistic technical change (OTC) of DMUo from time t to t + 1.

\textbf{MPI from the Pessimistic DEA}

When the efficiencies being computed from the pessimistic perspective, it is being called as pessimistic efficiencies. The following pessimistic DEA model quantifies the pessimistic efficiency of DMUo with respect to other DMUs (Wang, Chin & Yang, 2007; Wang & Chin, 2009):

Minimize \( \varphi_o = \sum_{r=1}^{p} \mu_r y_{ro} \)
subject to
\[
\sum_{i=1}^{m} \omega_i x_{io} = 1
\]
\[
\sum_{r=1}^{p} \mu_r y_{rj} - \sum_{i=1}^{m} \omega_i x_{ij} \geq 0, \quad j = 1, 2, \ldots, n
\]
\[
\mu_r, \omega_i \geq 0, \quad r = 1, 2, \ldots, p; \quad i = 1, 2, \ldots, m
\]

The dual of this linear programming model can be written as

Maximize \( \varphi_o \)
subject to
\[
\sum_{j=1}^{n} x_{ij} \lambda_j \geq \varphi_o x_{io} \quad i = 1, 2, \ldots, m
\]
\[
\sum_{j=1}^{n} y_{rj} \lambda_j \leq y_{ro} \quad r = 1, 2, \ldots, p
\]
\[
\lambda_j \geq 0, \quad j = 1, 2, \ldots, n.
\]

Therefore,
Maximize \( \varphi = D_0(t)(x_{0o}^{t}, y_{0o}^{t}) \)
subject to
\[ \sum_{j=1}^{n} \lambda_j x_{ij}^t \geq \varphi x_{io}^t, \quad i = 1, 2, \ldots, m, \]
\[ \sum_{j=1}^{n} \lambda_j x_{ij}^t + \lambda_j y_{rj}^t \leq y_{ro}^t, \quad r = 1, 2, \ldots, p, \]
\[ \lambda_j \geq 0, \quad j = 1, 2, \ldots, n, \]

Maximize \( \varphi = D_o^t(x_o^{t+1}, y_o^{t+1}) \)
subject to
\[ \sum_{j=1}^{n} \lambda_j x_{ij}^t \geq \varphi x_{io}^t, \quad i = 1, 2, \ldots, m, \]
\[ \sum_{j=1}^{n} \lambda_j x_{ij}^t + \lambda_j y_{rj}^t \leq y_{ro}^t, \quad r = 1, 2, \ldots, p, \]
\[ \lambda_j \geq 0, \quad j = 1, 2, \ldots, n, \]

Maximize \( \varphi = D_o^{t+1}(x_o^{t+1}, y_o^{t+1}) \)
subject to
\[ \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \geq \varphi x_{io}^{t+1}, \quad i = 1, 2, \ldots, m, \]
\[ \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} + \lambda_j y_{rj}^{t+1} \leq y_{ro}^{t+1}, \quad r = 1, 2, \ldots, p, \]
\[ \lambda_j \geq 0, \quad j = 1, 2, \ldots, n, \]

Maximize \( \varphi = D_o^{t+1}(x_o^{t}, y_o^{t}) \)
subject to
\[ \sum_{j=1}^{n} \lambda_j x_{ij}^{t} \geq \varphi x_{io}^{t}, \quad i = 1, 2, \ldots, m, \]
\[ \sum_{j=1}^{n} \lambda_j x_{ij}^{t} + \lambda_j y_{rj}^{t} \leq y_{ro}^{t}, \quad r = 1, 2, \ldots, p, \]
\[ \lambda_j \geq 0, \quad j = 1, 2, \ldots, n, \]

Where \( D_o^t(x_o^t, y_o^t) \) and \( D_o^{t+1}(x_o^{t+1}, y_o^{t+1}) \) computes the pessimistic efficiencies of DMU_o (\( o \in \{1, 2, \ldots, n\} \)) in time t and t+1, correspondingly, \( D_o^t(x_o^{t+1}, y_o^{t+1}) \) calculates its pessimistic efficiency in time t+1 using the technical efficiency of time t, and \( D_o^{t+1}(x_o^t, y_o^t) \) calculates the pessimistic efficiency of DMU_o for the time t using the technical efficiency of time t+1.

Therefore, the productivity changes from time t to t+1 can be represented as follows:

\[
\text{MPI}_o\text{(pessimistic)} = \left( \frac{D_o^t(x_o^{t+1}, y_o^{t+1})}{D_o^t(x_o^t, y_o^t)} \cdot \frac{D_o^{t+1}(x_o^{t+1}, y_o^{t+1})}{D_o^{t+1}(x_o^t, y_o^t)} \right)^{1/2}
\]
It is the geometric mean of two productivity indices measured from pessimistic DEA perspective. Considering the fact that proposed by Färe et al. (1992), MPI_{o (pessimistic)} > 1 indicates increase in productivity, MPI_{o (pessimistic)} = 1 signifies that productivity is unaffected, and MPI_{o (pessimistic)} < 1 specifies decreasing productivity.

As discussed above, the pessimistic DEA-based MPI can also be divided into two elements:

\[ \text{MPI}_{o (pessimistic)} = \left( \frac{D_{o}^{t+1}(x_{o}^{t+1}, y_{o}^{t+1})}{D_{o}^{t}(x_{o}^{t}, y_{o}^{t})} \cdot \frac{D_{o}^{t+1}(x_{o}^{t+1}, y_{o}^{t+1})}{D_{o}^{t+1}(x_{o}^{t}, y_{o}^{t})} \right)^{1/2} \]

\[ = \frac{D_{o}^{t+1}(x_{o}^{t+1}, y_{o}^{t+1})}{D_{o}^{t}(x_{o}^{t}, y_{o}^{t})} \left( \frac{D_{o}^{t}(x_{o}^{t}, y_{o}^{t})}{D_{o}^{t+1}(x_{o}^{t}, y_{o}^{t})} \cdot \frac{D_{o}^{t+1}(x_{o}^{t+1}, y_{o}^{t+1})}{D_{o}^{t+1}(x_{o}^{t}, y_{o}^{t})} \right)^{1/2} \]  

(16)

The first part is,

\[ PEC_{o} = \frac{D_{o}^{t+1}(x_{o}^{t+1}, y_{o}^{t+1})}{D_{o}^{t}(x_{o}^{t}, y_{o}^{t})} \]  

(17)

PEC_{o} measures the pessimistic efficiency change (PEC) for DMUo. PEC > 1 implies that there is an improvement in the optimistic efficiency of DMUo, while OEC < 1 signifies the opposite i.e., optimistic efficiency of DMUo has reduced. The second part is

\[ PTC_{o} = \left[ \frac{D_{o}^{t}(x_{o}^{t}, y_{o}^{t})}{D_{o}^{t+1}(x_{o}^{t}, y_{o}^{t})} \cdot \frac{D_{o}^{t}(x_{o}^{t}, y_{o}^{t})}{D_{o}^{t+1}(x_{o}^{t}, y_{o}^{t})} \right]^{1/2} \]

(18)

which calculates the pessimistic technical change (PTC) of DMUo from time t to t + 1.

**MPI Aggregation**

The MPI values calculated from both DEA perspectives are not equal, rather they are significantly different that may lead to different result as well as different conclusion. Therefore, it is very important to aggregate them into a combined MPI value to come up to a final result. As discussed before in the equation (5), the geometric mean of the optimistic and the pessimistic DEA based MPI values can give an integrated MPI value. Geometric mean
can reflect criticality of individual productivity value because the overall measure takes zero
value when any of the productivities takes the value zero irrespective of the other value.
Therefore,

\[
\text{MPIo} \text{ (DFDEA)} = [\text{MPIo}(\text{optimistic}) \cdot \text{MPIo}(\text{pessimistic})]^{1/2}, \quad (19)
\]

It is the typical productivity change of DMUo from the optimistic as well as the pessimistic
DEA perspectives and can be further decomposed into

\[
\text{MPIo}(\text{DFDEA}) = [(\text{OECo} \cdot \text{OTCo}) (\text{PECo} \cdot \text{PTCo})]^{1/2}
\]

\[
= [\text{OECo} \cdot \text{PECo}]^{1/2} \cdot [\text{OTCo} \cdot \text{PTCo}]^{1/2}
\]

\[
= \text{ECo} \cdot \text{TCo}, \quad (20)
\]

where \( \text{ECo} = [\text{OECo} \cdot \text{PECo}]^{1/2} \) and \( \text{TCo} = [\text{OTCo} \cdot \text{PTCo}]^{1/2} \) respectively represents the
average efficiency change of DMUo as well as technical change for the time \( t \) and \( t + 1 \). As
the MPI value delineated in the equation (19), it is the combination of the MPI values
calculated from the optimistic as well as the pessimistic DEA, therefore it is being called as
the MPI value based on double frontier DEA. It is more inclusive and pragmatic than the
traditional optimistic MPI value and it can precisely produce the time-based productivity
changes of the DMUs.

**Data and Results**

We received our data from those states of the US where casino gaming is legalized
and whose basic information is provided in the American Gaming Association (AGA). The
state-wise aggregated casino industry has been identified as DMU for our study. Based on the
availability of the secondary data during 2006 and 2012, a total of twelve states has been
considered as DMUs. All data needed for this study are collected from each state’s Gaming
Commission website and the American Gaming Association website. Instead of studying all

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2 They are Colorado, Illinois, Indiana, Iowa, Louisiana, Michigan, Mississippi, Missouri, Nevada,
New Jersey, Pennsylvania, South Dakota.
casino places including Indian casinos, this study uses only casinos that the AGA recognizes as current operating casinos. As MPI calculates productivity changes over time, we attempt to see the effect of the great recession on the casino industry performance and hence considered 2009 as baseline year and calculated the performance of the casinos during pre (2006-08) and post-recession (2010-12) years. As we already discussed, the returns to scale assumption is constant and the MPI is to be calculated based on CRS method, because a variable scale may lead to inaccurate output (Grifell-Tatjé & Lovell, 1995). The efficiency change and technical change indices are obtained under the assumption that the DMUs operates according to CRS, that is, assuming that DMU is operating in an optimal scale. According to Johnes (2006), the size of the DMUs can be presented by the number of people employed there. Over the time period considered, the correlation coefficient between number of employees in DMUs and their corresponding efficiency scores is very low (lies between -0.1 and 0.1), indicating no correlation between the size of DMUs and efficiency. Therefore, choice of CRS model is justified. The non-availability of data for the identified DMUs restrict us to consider for a longer time period. For the DEA analysis, we used R-programming language to calculate all efficiency scores.

We examine this new method to analyze the state-wise casino productivity changes in the US. Here, the inputs are aggregated as a) number of employees employed in the casinos, and b) total employee wages paid in that state; and the outputs have been identified as a) gross gaming revenue, and b) gaming tax revenue from each considered state. The input and outputs factors considered in the model are the state-wise sum of all the casino properties’ inputs and outputs. Being a service industry, casinos are labor intensive. Generally, labor cost for hospitality industry can account for around 33% of total revenues, and 43% of all operating expenses (Jones & Lockwood, 2002). Thus, it is not surprising that most studies on
hotel efficiency have included labor as an input (Assaf & Barros, 2011). Our selected outputs are the most common in related hospitality studies (Barros, 2005; Barros & Dieke, 2008).

**Results**

Initially, to get the optimistic DEA based MPI values, we run models (1) through (5) for each DMU and then to achieve the pessimistic DEA based MPI values, we run models (11) through (15). The results from our data sets are presented in Table 4, 5 and 6. It is clearly identifiable from our results that the two different DEA viewpoints based MPI values have noteworthy differences. Considering the state Louisiana (DMU5) as an example, from the optimistic DEA perspective, Louisiana made progress in its gaming economy productivity during the period 2006-2012. In the pre-recession years considered for our study, the productivity growth rates for its gaming economy were 11.44% for the year 2006, 1.73% for 2007, 4.55% for 2008; and for the post-recession years they were 0.81% for 2010, 0.6% for 2011 and 14.45% for 2012. On average, the yearly productivity increment rate for Louisiana DMU’s gaming economy shows as positive and it was 5.91% during the pre-recession years and 5.29% during the post-recession period of our study. On the other hand, from the pessimistic DEA perspective, Louisiana failed to accomplish productivity progress in the post-recession year 2011. More precisely, its productivity declined by 1.03% in the year 2011. Such a conclusion is perceptibly in conflict with the optimistic DEA results that shows the efficiency of Louisiana gaming economy improved by 0.6% in the year 2011. These two evaluations are apparently correct, but they are from different perspectives. They should be provided collectively to analyze the productivity changes of the gaming economy of the US systematically and accurately.

In obtaining an overall assessment for the 12 DMUs, Table 6 shows the DFDEA-based MPI values combining both the optimistic and the pessimistic DEA points of view simultaneously for each DMU as suggested in the model (19). These comprehensive DFDEA MPI values reveal that the gaming economy of Louisiana experienced a productivity decline
of 0.22% in the year 2011. This is in conflict with the traditional optimistic DEA results, which shows its productivity growth for the said year is positive. The average productivity growth rates for Louisiana gaming economy in the other time periods are 8.13%, 1.87%, 5.86 for the years 2006, 2007, 2008 and 0.82%, -0.22%, 14.27% for the years 2010, 2011, 2012 respectively. The other DMUs may be examined in the same way.

From the average results in Table 6, it is observed that out of the 12 states of the US, seven of them showed negative productivity growth in their gaming economy for the year 2008, preceding the baseline year 2009. However, in the succeeding year 2010 only three of them (Colorado, New Jersey and Pennsylvania) were still to recovered from negative productivity growth, rest all of them showed a positive productivity growth. In particular, the gaming economy of Illinois experienced a highest productivity growth during the pre-recession years (annual average growth rate of 16.77%) and whereas the same happened with South Dakota for the post-recession years (annual average growth rate of 14.27%). On the other hand, the state of Iowa experienced the highest productivity decline during the pre-recession years (annual average decline rate of 10.03%) and whereas for the post-recession years the same happened with New Jersey (annual average decline rate of 9.04%). The results we presented through the plots (Figure 2) are not completely in line with the results we received from traditional optimistic results. Finally, the double frontier MPI values for pre and post-recession years suggest the productivity growths were negative for five out of 12 states presented in our sample for the year 2006, however in the year 2008, seven states out of 12 (58.33% of the total) showed negative productivity growths indicating that a large proportion of US casinos have experienced a decrease in productivity for that year (the actual year of recession).
Discussion

This study is a pioneering work in measuring Malmquist Index considering both frontiers of DEA. This paper calculates the DFDEA based MPI to evaluate the productivity of the casino industry for various states of the United States. The traditional DEA-based MPI uses optimistic DEA models for productivity measurement revealing the productivity changes from the optimistic DEA perspective. In this study, a novel approach namely double frontier DEA has been proposed for MPI measurement from the optimistic as well as the pessimistic DEA perspective concurrently. The DFDEA-based MPI reflects the optimistic efficiency as well as pessimistic efficiency changes of the DMUs. In addition to the traditional shifts of efficiency frontiers, it also considers the movements of inefficiency frontiers. Therefore, we can construe that the DFDEA is a more inclusive and accurate approach than the traditional optimistic DEA-based MPI.

From the results it can be observed that the MPI values calculated from the pessimistic DEA perspective are unlike from those computed from the optimistic DEA perspective and sometimes pessimistic perspective has bigger weight that the optimistic ones. For example, in the state of Pennsylvania, we have observed that the pessimistic MPI has got bigger values than the optimistic ones and it substantially impacted the overall productivity of the state. It is clear that some of the US states like Indiana, Michigan, Missouri, Nevada and South Dakota maintained their steady productivity growth during post-recession time period; while the other states in our sample showed fluctuating productivity. It is also clear that some states took a decision of sacrificing their revenues for maintaining the similar employment generation during the recession time periods, as in such situations it becomes common to lay off employees in order to maintain better productivity (Del Mar Alonso-Almeida, & Bremer, 2013; Roche et al., 2011).
From the figure 2 it is very clear that most of the states showed an upward productivity trend during the post-recession time period except two states (Iowa and New Jersey). There possible reasons for that. Being a mid-western state, Iowa’s gaming industry did not lay off its employees rather they continually increased their workforce in the post-recession period, however, their gaming revenue didn’t increase that way, leading to decrease in the industry productivity. The results show that there is scope to improve efficiency in the US gaming industry. The best practicing states have been identified and the inefficient states should follow these benchmarks in order to increase their performance. The states like Illinois, South Dakota has become more efficient than the other states in the post-recession time period although they generate less amount of revenue. The results provide an explanation of the US gaming tourism paradox in the hospitality sector. It means that, except for the upscale and luxury gaming destination like Las Vegas or Atlanta which are not specifically analyzed in this study, gaming tourists tend to reduce their expenditure by choosing small destinations. Consumer spending on gaming represents discretionary spending (Zheng, Farrish, Lee & Yu, 2013). It is not necessary that the consumers’ discretionary spending will disappear during and post-recessions periods, nor their tastes necessarily change, rather the spending volume decreases. Now in such scenario, if consumers find less expensive ways to spend their discretionary income in the same way as they were doing before recession, then they will always go for that. Therefore, the marketers of non-destination casinos should promote their business in the local markets, in a much aggressive way and retain customers as they generally travel to the big destinations and spend higher amount of money to get the same experience. US gaming policymakers and casino operators should take a note of this finding and accordingly casino operators should frame their marketing strategies’.
Conclusion

The MPI values measured both from the optimistic and pessimistic DEA perspectives, provide a panoramic view of the productivity changes over time. The outcomes of this study will therefore be more objective and accurate than previous studies. Unlike a static framework, this method yields a comparison of a state’s casino industry - considered to be a DMU - with respect to its own past performance as well as the performance of the other states. This method helps identify the benchmark of casino economic impact by comparing all DMUs to provide a comprehensive index for measuring their overall efficiency. By performing DFDEA on the number of employees, and total employee wage, gross gaming revenue, and gaming tax revenue of each state’s casino, this research model is designed to determine the optimal benchmark for commercial casinos. Moreover, the methodology in itself can represent an important tool for policy makers, through the identification of a number of policy strategies that appear to be crucial for the evolution of the future casino debate.

Our results can assist investors seeking further information about the state wise casino status in the US. Government policy makers might also incorporate these results into their strategic plans as the casinos do not have productivity information available with them. Further extensions and validations of the present study are possible. So far as the data for the analysis is concerned, we have considered secondary published data which has got its own limitations. Also, the choice of the input and output variables are limited due to the lack of accessibility to real data. Therefore, future research could further explore efficiency improvements in the casino industry by using more appropriate input and output variables, internal and external factors, if accessible, or by extending it to different states that has not been covered in this study because of limited availability of data. For example, if researchers
can access the information related to coin-in and/or table drop revenue in states where it is not publicly available, the study will be able to provide different managerial perspectives.

References


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| Aissa and Goaied (2016)        | DEA and ROA       | 27 Tunisian hotel            | 3) Direct expenses  
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| Fernández and Becerra (2015)   | DEA               | 166 Spanish hotels           | 3) Number of rooms  
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| Huang, Ho and Chiu (2014)      | Modified two-stage DEA model | 58 Taiwanese international tourist hotels | 1) Operating expense (in millions of NT$)  
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<tr>
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<td>Year 2012</td>
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<td></td>
</tr>
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<td>-----------</td>
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</table>

**Table 3: Gaming data for the year 2010, 2011, 2012**
Table 4
Optimistic MPI values (%) with 2009 as baseline

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<th>State (DMUs)</th>
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<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
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</tr>
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<td>96.24</td>
<td>100.23</td>
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<tr>
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Table 5
Pessimistic MPI values (%) with 2009 as baseline

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<th>State (DMUs)</th>
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<th>2007</th>
<th>2008</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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<td>108.24</td>
</tr>
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</tr>
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</tr>
<tr>
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<td>100.04</td>
<td>102.07</td>
<td>108.02</td>
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</tr>
<tr>
<td>New Jersey</td>
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<td>109.09</td>
<td>107.74</td>
<td>96.30</td>
<td>93.22</td>
<td>81.02</td>
</tr>
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<td>127.40</td>
<td>91.00</td>
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<td>143.87</td>
</tr>
<tr>
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<td>109.17</td>
<td>107.94</td>
<td>121.57</td>
<td>106.12</td>
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Table 6
Double frontier MPI values (%) with 2009 as baseline

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<th>2010</th>
<th>2011</th>
<th>2012</th>
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<td>95.85</td>
<td>95.77</td>
<td>103.48</td>
<td>105.79</td>
</tr>
<tr>
<td>Illinois</td>
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<td>121.01</td>
<td>103.36</td>
<td>100.27</td>
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<td>106.95</td>
</tr>
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<td>105.86</td>
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Table 6 Continued

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<td>108.79</td>
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<td>107.98</td>
<td>118.03</td>
<td>110.25</td>
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</table>

Figure 1

*International tourism receipts*
Figure 2
State-wise gaming productivity changes over time
CHAPTER 6. GENERAL CONCLUSION

This study proposed a new efficiency measurement technique and thereby advancing quantitative data analysis methodology for performance measurement. This chapter summarizes the major findings from this work to draw conclusions and make recommendations. There are three main sections in this chapter. The first section summarizes results and key findings from this work. The second section comprises discussion and implications of this study. Finally, the last section provides limitations and recommendations for future research in this area.

Summary of Results and Key Findings

This study measures efficiency of casinos operating in the United States. In our first model, casinos from 24 states across the United States where casino gaming is legalized and whose basic information is provided with the AGA were studied. This method helped in identifying the benchmark of casino economic impact by comparing different states’ casino industry to provide a comprehensive index for measuring their overall efficiency. Casinos’ performances were evaluated by the output oriented CCR and BCC models (Charnes et al., 1978; Banker et al., 1984) and eventually efficiency scores were calculated. By performing the DEA technique on slot machines, square feet of gaming space, gross revenue, number of employees, wage per employee and gaming tax revenue of each state’s casino, these models were designed to determine the optimal benchmark for commercial casinos. The results demonstrate that significant economic impact created by more than the half of the states. Among twenty-four states, thirteen states were efficient with respect to the output-oriented BCC model.

Findings from our first project suggest that less efficient states’ casinos could improve the level of their employment through the slacks identified (for example, slack in the input variable slot machine and output variable per capita wage for some of the states) from CCR and
BCC models. In addition, casino practitioners may apply this benchmark research model to evaluate their casinos’ economic impact, especially in terms of employment. Finally, the findings provide decision makers with a better understanding of how exactly the casinos affect their community and how to enhance their existing casinos’ productivity. For instance, many businesses cease to exist because of their operational inefficiency (Frei, 2006), one reason for this is inefficient use of labor. On the other hand, inefficient use of labor might also be an indication of too few employees and such businesses must necessarily experience service problems. Increasing employment in those states to improve service quality for the business and creating better economic impact for the community is recommended.

The quantitative model proposed in the second project of this study is a pioneering work in measuring MPI to evaluate the efficiency change over time for the casino industry of the United States by considering both optimistic and pessimistic frontiers of DEA model. Here, as we considered 6-year longitudinal data of gaming (between 2006 and 2012, pre and post-recession scenario, considering 2009 as the baseline year), therefore MPI was the best suitable method to be used in such context as MPI considers the production frontiers can shift over time. The traditional DEA-based MPI uses optimistic DEA models for productivity measurement revealing the productivity changes from the optimistic DEA perspective. In this study, a novel approach namely DFDEA has been proposed for MPI measurement from the optimistic as well as the pessimistic DEA perspectives concurrently. The DFDEA-based MPI reflects the optimistic efficiency as well as pessimistic efficiency changes of the DMUs. In addition to the traditional shifts of efficiency frontiers, this model also considers the movements of inefficient frontiers. Therefore, we can construe that the DFDEA is a more inclusive and accurate approach than the traditional optimistic DEA-based MPI measuring approach.
From the results we obtained from this model, it can be observed that the MPI values calculated from the pessimistic DEA perspective are unlike those computed from the optimistic DEA perspective, and sometimes the pessimistic perspective has bigger weight than the optimistic ones. For example, in the state of Pennsylvania, we have observed the pessimistic MPI has got bigger values than the optimistic ones and it substantially impacted the overall productivity of the state. It is clear that some of the US states like Indiana, Michigan, Missouri, Nevada and South Dakota maintained their steady productivity growth during post-recession time period; while the other states in our sample showed fluctuating productivity. It is also clear that some states made the decision to sacrifice their revenues for maintaining the similar employment generation during the recession time periods, as in such situations it becomes common to lay off employees in order to maintain better productivity (Del Mar Alonso-Almeida, & Bremser, 2013; Roche et al., 2011; Zheng & Hung, 2012).

From the outcome of the second project of this study, it is also very clear that most of the states showed perpetuating upward productivity trends during the post-recession time period, except two states (Iowa and New Jersey). There are possible reasons for that. Being a mid-western state, Iowa’s gaming industry did not lay off its employees, rather they continually increased their workforce in the post-recession period; however, their gaming revenue did not increase that way, leading to a decrease in their productivity. The results show there is a scope to improve efficiency in the US gaming industry. The best practicing states have been identified, and the inefficient states should follow these benchmarks in order to increase their performance. The Mid-Western states like Indiana, Iowa, Missouri and South Dakota have become more efficient than the other states in the post-recession time period, although their revenue generation is not that significant compare to the entire US gaming industry.
Discussion and Implications

None of the past studies examined the efficiency levels of casinos at the state level and consequently their impact on the country’s economy. Our study extends the existing DEA model for quantitative data analysis while examining the economic impact of the US gaming industry. Findings from this study highlight the importance of our proposed model in better state level efficiency measurement for the gaming industry and their impact on the US economy.

This study demonstrates ways through which casino performance could be improved to optimize benefits to local economies, as well as profitability for the casino operators as business organizations are primarily concerned with optimizing benefits for their shareholders (Bandyopadhayay & Roy, 2012; Bandyopadhayay & Banerjee, 2017). If we assume that casino organizations are already operating in ways that best serve their interests, the proposed mechanism for efficiency computation will at least help achieving better benefits for the communities in which they exist, which is enough of a reason to adopt these recommendations for both the casino operators and the state and local governments in which they operate.

This study also measures MPI values both from the optimistic and pessimistic DEA perspectives, thereby providing a panoramic view of the productivity changes over time. The outcomes of this study are more objective and accurate than previous studies. Unlike a static framework, the methodologies proposed here yield a comparison of a state’s casino industry with respect to its own past performance as well as the performance of the other states. The outcome of this study helps identify the benchmark of casino economic impact by comparing all available states to provide a comprehensive index for measuring their overall efficiency. By performing DFDEA on the number of employees, total employee wage, gross gaming revenue, and gaming tax revenue of each state’s casino, this research model is designed to determine the optimal benchmark for commercial casinos. Moreover, the proposed methodology advances data
analytics methodology. Additionally, this methodology can represent an important tool for policy makers, through the identification of a number of policy strategies that appear to be crucial for the evolution of the future casino debate.

So far as the practical implications of our study are concerned, our findings will assist investors seeking further information about the state-wide casino status, and the US government policy makers might also incorporate these results while framing their strategic plans for this industry. The outcome of this study provides an explanation of the US gaming tourism paradox in the hospitality sector, which means, except for the upscale and luxury gaming destinations like Las Vegas or Atlanta, which are not precisely analyzed in this study, gaming tourists tend to reduce their expenditure during recession and/or post-recession periods by choosing small destinations. Consumer spending on gaming represents discretionary spending (Zheng, Farrish, Lee & Yu, 2013; Zheng, Farrish & Kitterlin, 2016). It is not necessary that the consumers’ discretionary spending will disappear during recession and post-recessions periods, nor do their tastes necessarily change, rather the spending volume decreases. In such a scenario, if consumers find less expensive ways to spend their discretionary income in the same way as they were doing before the recession, then they will always go for that. Therefore, marketers of non-destination casinos should promote their business in the local markets, in a more aggressive way and put every possible effort to retain customers as they generally travel to the big destinations and spend higher amounts of money to get the same experience. In doing so, non-destination casino promoters need to invest more in providing better experiences to their customers, which in turn will impact the local economy through more job creation, better tax revenue collection etc. US gaming policymakers and casino operators should take note of it, and accordingly casino operators should frame their marketing strategies’.
**Limitations and Future Research**

It would be inappropriate to label any research as perfect and free from all limitations. Similarly, our study has many factors that can be considered as its limitations. First, due to the lack of accessibility to useful data, we had a limited choice of considering the input and output variables. For example, accommodation facilities, population of a state, their income level, number of tourists visiting those states, special events etc. may be considered as the input and output variables. Therefore, we propose future research that could further explore efficiency improvements in the casino industry by using varied input and output variables as well as internal and external factors, if accessible. This study can also be extended to different states that cannot be covered because of limited availability of data. For example, if researchers can access the information related to coin-in and/or table drop revenue in states where it is not publicly available, the study will be able to provide different managerial perspectives. Second, we have considered secondary data in our study which has its own limitations. Finally, future research may use the novel efficiency measurement methodology that we proposed in measuring efficiency for other research and business communities.

**References**


